

Waste Audit Study: Research and Educational Institutions

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16. Abstract (Limit: 200 words) This document reports on hazardous waste reduction audits performed at three diverse research/educational institutions in southern California. Waste reduction opportunities identified include: utilizing microscale experiments; chemical substitution; treating waste chemicals in the final step in experiments; and recycle, recovery, and treatment options. A generic self-audit was developed for use by educational and research institutions throughout the state.		13. Type of Report & Period Covered 14.	
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**WASTE
AUDIT STUDY**

**RESEARCH AND
EDUCATIONAL
INSTITUTIONS**

PREPARED FOR

**ALTERNATIVE TECHNOLOGY SECTION
TOXIC SUBSTANCES CONTROL DIVISION**

**CALIFORNIA DEPARTMENT OF
HEALTH SERVICES**

PREPARED BY

RALPH STONE AND CO., INC.

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LOS ANGELES, CA 90025**

AUGUST 1988

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RALPH STONE AND COMPANY, INC.

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OF
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ALTERNATIVE TECHNOLOGY SECTION
714/744 P STREET
SACRAMENTO, CALIFORNIA

AUGUST 15, 1988

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ABSTRACT

Hazardous Waste Reduction Audits were performed at three diverse research/educational institutions in the southern California region. The audits were performed to determine ways these types of institutions can reduce the generation of hazardous waste. The three institutions chosen included a large university, a small four year liberal arts college, and a technical research institute. Numerous waste reduction opportunities were identified from audits conducted at each of these institutions. These opportunities include utilizing microscale experiments; chemical substitution; treating waste chemicals in the final step in experiments; and recycle, recovery and treatment options. The institutions expressed concern about some existing regulations that are barriers to waste reduction. A generic self-audit was developed for use by educational and research institutions throughout the state.

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DISCLAIMER

The statements and conclusions of the report are those of the Contractor and not necessarily those of the State of California. The mention of commercial products, their source or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products.

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CHAPTER 1

SUMMARY AND CONCLUSIONS

1.1 Scope

Hazardous waste generation at educational and research institutions contrasts with that of most industrial generators. An institution uses small quantities of a broad spectrum of chemicals. The waste generated consists of small quantities of many different chemicals. An industrial generator usually has a few different waste streams generated in large quantities. This difference requires the institutions to use a unique waste reduction strategy.

Hazardous waste audits were conducted at three different educational/research institutions in southern California:

1. A small, private, liberal arts college
2. A large university
3. A technical research institute

These institutions were selected to represent the types of educational/research institutions in the state.

1.2 Hazardous Waste Sources

Chemical waste generation comes from:

- Chemistry and biology laboratories, both teaching and research
- Physics, geology, psychology and engineering laboratories
- Art programs
- Plant and maintenance operations
- Photography, printing operations (including the school newspaper and fine arts programs)
- Agricultural programs

In each institution audited the chemistry department generated the largest quantity of waste. The biology department generated the second largest amount. In these departments, graduate research generated more waste than the undergraduate program.

1.3 Hazardous Waste Description

Wastes are usually generated in quantities of less than one gallon. Typical wastes are inorganic acids and bases, organic solvents, metals, a large number of dry powders, reaction products from experiments; photography waste, vehicle maintenance waste, waste paint, and small quantities of other wastes. Laboratory wastes are in the form of mixtures, contaminated solutions and substances, and unused reagent chemicals.

1.4 Waste Management Practices

The college has no formal hazardous waste management program. The university has a program which oversees disposal, recycling and treatment of waste chemicals. The institute has an extensive program which supervises and handles disposal of all waste chemicals.

Chemistry professors at the university and the institute were aware of environmental laws and safety issues pertaining to their activities. That awareness was significantly lower at the college. At all three, professors in other disciplines such as biology were unaware of disposal requirements or hazards associated with use of certain chemicals. Graduate students in chemistry and biology were not trained in the hazards associated with chemicals they handle, nor in the proper disposal techniques.

The EPA estimates that the total amount of hazardous waste generated by research/educational institutions is from 2,000 to 4,000 metric tons per year (17). This is less than one percent of the national total of hazardous waste generated annually. The EPA study also found that schools with large scientific research programs tend to have more developed hazardous waste management programs.

1.5 Existing Disposal Practices

Disposal in lab packs is the most common disposal practice at

the three institutions. Small bottles of laboratory waste are segregated by compatibility of contents and are packaged in drums with absorbent cushioning to prevent breakage, as required for lab packs. The drums are then shipped to a Class I landfill for disposal.

1.6 Waste Reduction Strategies

Each institution audited had a hazardous waste reduction strategy. These included:

- Reducing the scale of undergraduate chemistry laboratory experiments. This reduces the volume of chemicals used.
- Eliminating the use of carcinogenic chemicals such as benzene and chloroform.
- Increasing the use of instrumentation. This decreases the amount of chemicals needed for experiments.
- In maintenance operations, eliminating the use of oil-based paints and reducing generation of pesticide waste.

At the university and institute additional strategies included:

- Establishing an internal recycling program. Unused reagents are collected and stored in a central storeroom. A list of the available chemicals is circulated to all potential users.
- Investigate improving inventory control by the use of "barcodes" for incoming chemicals, similar to barcodes used in supermarkets.

These waste reduction strategies have decreased chemical usage by as much as tenfold. Improvements have occurred in all disciplines.

Strategies listed above and others are discussed in Chapter 2. Many of these could also be implemented at high schools and vocational training schools.

1.7 Waste Audit Format

As part of this study a waste audit form has been developed for use by any learning institution. The form is self-explanatory. It identifies specific waste reduction opportunities that are workable and cost-effective. The waste audit begins at the administrative level, and then proceeds to the departmental level and finally to individual laboratories. The audit can be done of the whole institution or it can be limited to individual departments or laboratories.

1.8 Institution Concerns Regarding Hazardous Waste Reduction

Hazardous wastes from institutions include thousands of different chemicals. Most are generated in very small quantities. In the opinions of the institutions studied current laws are tailored to larger quantities from industry sources. As a result, the institutions expressed concern that certain laws are barriers to their waste reduction efforts. Their concerns include:

- Inability to use, without regulation, on-site furnaces to burn as a fuel supplement high BTU waste solvents such as alcohols, ketones, alkanes, and others. Complex and costly controls imposed by government agencies are significant impediments.
- Transportation requirements which generally prohibit unregulated shipment of unused reagent chemicals between schools.
- Excessive paperwork required for disposal of waste laboratory chemicals.
- Complex permit requirements for on-site treatment of many waste chemicals.

The Department of Health Services believes that most of the current hazardous waste control regulations should continue to apply to educational institutions. For example burning hazardous waste requires a permit because health hazards might result from improper incineration. Recordkeeping requirements are detailed to maintain "cradle-to-grave" control over hazardous waste.

1.9 Conclusion

The present study found that the university and institute have established waste management programs. The college had no formal program. This finding correlates with EPA's findings (17). The historical reason for this is that large institutions have needed formal programs addressing disposal of radioactive and special-hazard chemical wastes. When hazardous waste control laws and regulations were implemented in the early 1970's, these existing programs were expanded to deal with the collection of all regulated wastes.

The effectiveness of waste management programs is directly proportional to the following factors:

- Administrative commitment to compliance with environmental laws and regulations.
- Adequate staffing for carrying out the program.
- Availability of special storage areas for storing and segregating hazardous wastes.

This study found that schools that are part of a statewide school system have more difficulty implementing and expanding hazardous waste management programs. There are many levels of administrative bureaucracy that control policy and funding decisions regarding waste management.

The driving forces for waste reduction were found to be safety concerns, economics and technological advances. Safety concerns have resulted in elimination of many carcinogenic compounds from institutional use. Economic efficiency (cost cutting) has been the incentive for reducing the volume of chemicals used and recycling. Technological advances have reduced the amounts of chemicals required for qualitative and quantitative analyses. Instrumental analysis uses one-tenth to one-hundredth the volume typically used in wet chemistry techniques.

Records at two of the three institutions were limited to Hazardous Waste Manifests only. One institution had internal shipping records, but these did not indicate specific generators of waste streams. This lack of data hinders development of waste reduction opportunities. Better records would

allow comprehensive evaluation of the opportunities.

The upcoming restriction on land disposal of many hazardous chemicals commonly disposed of in lab packs will force institutions to implement waste reduction strategies. Utilizing the "Waste Reduction Audit" found in Chapter 5, and implementing the waste reduction opportunities contained in it, will prepare institutions for the lab pack disposal restrictions to be implemented in 1989.

CHAPTER 2

RECOMMENDATIONS

2.1 Waste Reduction Strategies

Most hazardous waste generated at educational/research institutions comes from laboratories. Many innovative waste reduction opportunities can reduce the volume and toxicity of laboratory waste generated. There are also reduction opportunities for non-laboratory wastes. These include wastes from art studios, photography, printing, and maintenance operations. The Alternative Technology Section is also conducting waste audit studies on some of these other services.

This study found institutions were already implementing many waste reduction opportunities.

2.1.1 Waste Reduction Through Management Practices

Inventory control can effectively reduce waste generation. None of the institutions audited fully used this option. If computer facilities are available it would be best to do this on a data base tracking system. Effective inventory control will help reduce chemical usage by:

- Identifying common users of a particular chemical. This will increase the sharing of chemicals between departments and instructors
- Identifying the high volume chemical users
- Notifying users of chemicals with limited shelf life to use up old stock before ordering or using new stock. Such chemicals should only be ordered when needed, to avoid outdated inventory.
- Allowing implementation of purchasing policies such as staggered deliveries, "buy as you need", etc. Purchase of a chemical in several small bottles rather than one large bottle, may allow longer chemical life and easier management of unused amounts.
- Encourage responsible participation by chemical suppliers by ordering chemicals from suppliers who can provide quick delivery of small orders, who will accept return

of unopened stock, and who offer off-site waste management outlets or cooperatives for laboratory wastes.

- Monitoring chemical flows from the time they arrive on campus to the time they leave as waste.
- Developing up-to-date listings of unused reagent chemicals that can be recycled for use by other laboratories

Education on waste reduction opportunities can enhance efforts to reduce the volume of waste generated. This can occur through departmental meetings, memos and seminars. Information communicated should include why reduction is important and available opportunities. The generators should have a training program for all faculty and staff who generate or handle hazardous waste.

Implementing a college-wide waste reduction program allows for a coordinated approach to addressing each area or department generating waste. The program should be prioritized by addressing campus-wide generation first, then chemistry, biology, other science departments, art, photography, and maintenance functions. The "Self-Audit" found in Chapter 5 uses this approach.

2.1.2 Waste Reduction Through Laboratory/Operations Practices

Practices that can reduce waste generation include the following:

- Reduce or eliminate the use of benzene, carbon tetrachloride, acetonitrile, mercury, lead, formaldehyde and other highly toxic chemicals in laboratory experiments.
- Scale down the volumes of chemicals used in laboratory experiments.
- Increase use of instrumentation.
- Treat or destroy hazardous waste products as the last step in experiments. This may not require a permit if the step is part of the educational process or experiment program.
- Replace oil-based paints with water-based paints in art

instruction and maintenance operations.

- Keep individual waste streams segregated. Keep hazardous waste segregated from nonhazardous waste. Keep recyclable waste segregated from non-recyclable waste. Minimize dilution of hazardous waste.

2.2 Changes In Existing Statutes

All three institutions stated that certain legislative changes would help promote waste reduction. In their opinions environmental statutes were developed for industrial waste generators, not for educational/research generators. Audited institutions recommended the following changes:

- Establish "Amnesty Days" monthly or every other month when the Department of Transportation requirements for chemical shipments would be suspended for school personnel. This would allow transport of surplus reagent chemicals between schools and colleges. This is being done in Minnesota and is helping to promote exchange of surplus chemicals between secondary schools, colleges, and universities.
- Reduce permit requirements for on-site burning of small quantities of high BTU value solvents in furnaces. Most educational institutions have furnaces that reach temperatures in excess of 2000 degrees F. Solvents could be fed into a furnace at low percentages with an atomizer. This procedure presently requires a DHS permit in order to implement it.
- Relax permit requirements for on-site treatment of waste chemicals. On-site treatment includes neutralization, hydrolysis, oxidation, reduction, incineration, and others.

Section 4.4 contains an additional discussion of regulatory recommendations and a government assessment of these recommendations.

CHAPTER 3

INTRODUCTION

3.1 Background

The Alternative Technology Section, Toxic Substances Control Division of the California Department of Health Services in its effort to promote source reduction is funding Waste Audit Studies of a wide number of industries. Educational and non-profit research institutions were included in this program because of the need to develop waste reduction opportunities for this group.

The objective of the current study was to conduct waste audits at three diverse educational/research institutions. The following were selected:

- A large university
- A technical research institute
- A small, private, liberal arts college

The above represents common types of institutions found in the state.

3.2 Laboratory Waste Generation

Most chemical waste generation comes from laboratories. This includes hundreds or thousands of different chemicals generated in quantities of from 1 gram up to 55-gallon drums. The disposal method most often used is lab packs. Lab pack disposal is used for 100% of the waste at the college, 80% at the university and 50% at the research institute.

Chemistry departments generate the largest quantity and diversity of waste. Research laboratories generate more waste than teaching laboratories. Table 3-1 lists typical wastes generated in chemistry laboratories. Biology is the second highest generating department. Chemicals used in biology are less varied than in chemistry and generation is typically under one gallon per waste type.

TABLE 3-1: TYPICAL HAZARDOUS WASTE GENERATED IN CHEMISTRY LABORATORIES AT EDUCATIONAL/RESEARCH INSTITUTIONS

1. Trash, inert chemicals - non-toxic, non-reactive, non-ignitable, non-corrosive solids as per RCRA guidelines. Becomes a hazardous waste if commingled with hazardous waste.
2. Weak aqueous acid solutions (less than 10% wt.) and related compounds.
3. Weak aqueous alkaline solutions (less than 10% wt.) and related compounds.
4. Concentrated aqueous acid solutions and related compounds.
5. Concentrated aqueous alkaline solutions and related compounds.
6. Flammable (flash point, closed-cup, less than 140 degrees F), non-halogenated organic solvents and related compounds.
7. Flammable halogenated organic solvents and related compounds.
8. Non-flammable non-halogenated organic solvents and related compounds.
9. Non-flammable halogenated organic solvents and related compounds.
10. Organic acids
11. Organic bases.
12. Inorganic oxidizers, peroxides.
13. Organic oxidizers, peroxides.
14. Toxic-heavy chemicals.
15. Toxic - poisons, herbicides, pesticides, carcinogens.

TABLE 3-1 (CONT.)

16. Aqueous solutions of reducing agents and related compounds.
17. Pyrophoric substances.
18. Hydrophoric substances.
19. Cyanide, sulfide, ammonia bearing waste.
20. Explosive materials.
21. Radioactive materials.
22. Water soluble waste of unknown origin or properties.
23. Water insoluble waste of unknown origin or properties.
24. Empty containers.
25. Contaminated lab ware, trash, etc.

Biology research laboratories generate more waste than teaching laboratories.

Other departments with laboratories are geology, physics, psychology and engineering. Wastes from these laboratories are less than biology, typically under one quart per waste type.

Figure 3-1 shows a comparison of quantities of hazardous waste generated at the three audited institutions. Most laboratory waste is mixtures, solutions, contaminated substances, and surplus reagent chemicals. Waste oil is also generated in many laboratories.

When professors leave the institution, they typically leave a large amount of laboratory chemicals. These include unused reagent chemicals, unlabeled containers, and an assortment of mixtures and solutions. Unlabeled containers present a waste management problem.

3.3 Other Waste Generation

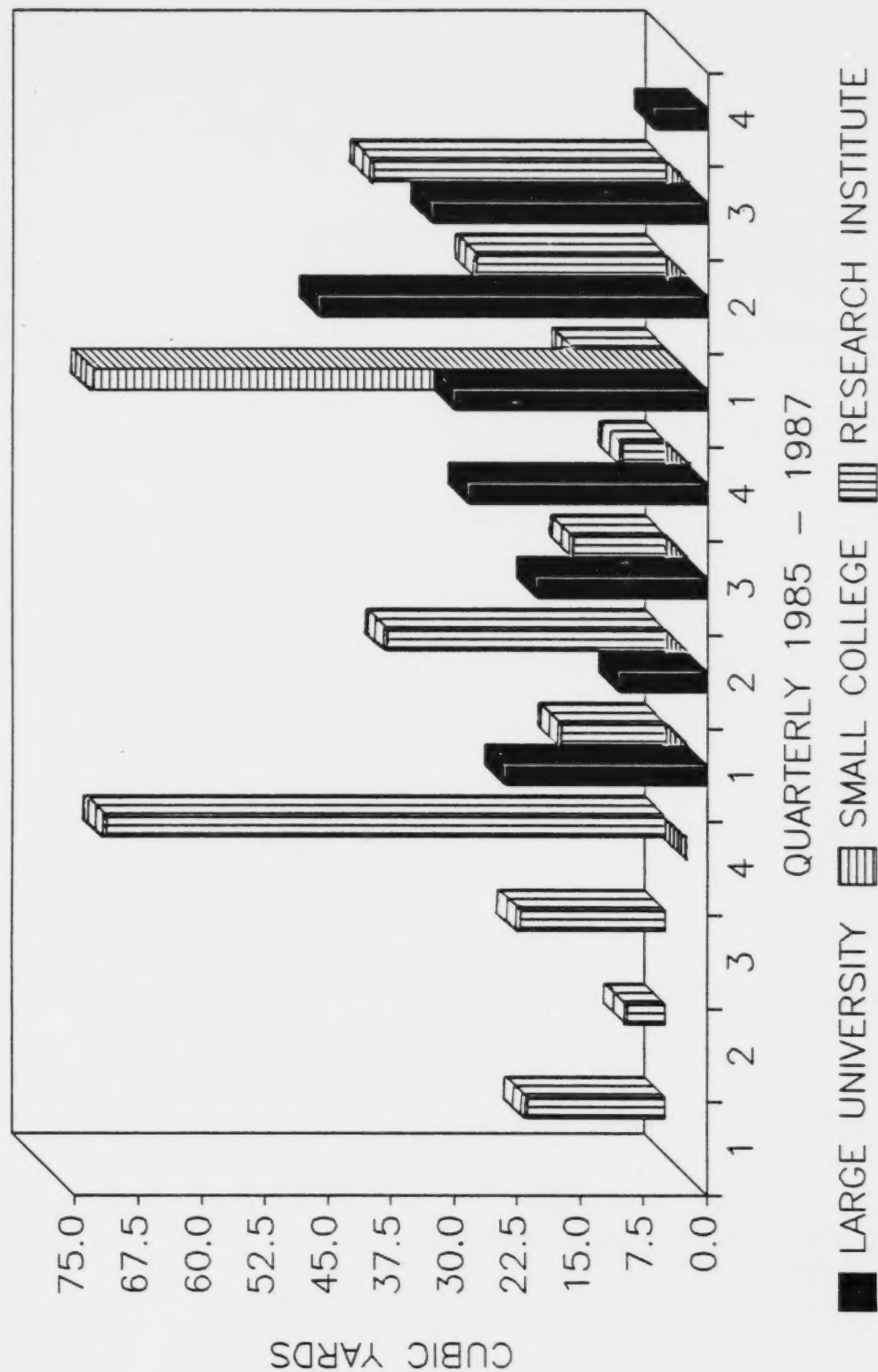
Art, printing, photography, and institution maintenance also generate chemical waste. Art waste includes paints, thinners, other solvents and heavy metals. Printing operations generate waste inks and solvents. Photographic processing generates waste silver and cleaning solutions. Maintenance operations generate waste oils, solvents, pesticides, water treatment chemicals, and PCB oil from old transformers.

3.4 Waste Management Programs

The University of Illinois disposed of 7,300 containers holding more than 2,100 different chemicals and mixtures in 1984. The University of Massachusetts, Amherst disposes of approximately 2,000 different chemicals and mixtures each year. The size of individual waste containers range from a 55-gallon drum to an ampoule (14).

Awareness of environmental issues varied. The chemistry departments were more aware of chemical hazards and proper disposal than other departments. Chemistry departments are typically the focal points of hazardous waste programs at educational/research institutions.

FIGURE 3-1
TOTAL WASTE PER QUARTER
DISPOSED OF BY AUDITED INSTITUTION



Graduate research students at the large university were not informed about chemical hazards and proper disposal techniques. Their awareness is a function of their undergraduate training and the current department/institution policy. Molecular biological researchers audited expressed the need for more information regarding these issues.

Campus administration commitment to proper waste management varied. The institute provided the largest staff for waste management. The university provided minimal staffing to meet waste management needs. The college had only professors and chemical stockroom clerks to administer waste management. These individuals performed waste management tasks in addition to their other duties.

The EPA found that campuses with large research programs have extensive waste management programs (17). The quantity of waste generated and the need to keep disposal and liability costs down were the factors for establishing waste management programs.

Secondary and vocational schools generate chemical waste. In secondary schools waste is generated in science laboratories, arts, crafts and vocational studies (17). Table 3-2 shows typical waste generation in secondary schools.

Regulatory agencies have not, up until recently, enforced environmental and safety regulations at secondary schools. As a result, little or no effort on the part of the school district administrators was put into hazardous material management. The EPA found (17) that several school districts studied had no budget at all for dealing with hazardous materials. EPA researchers encountered some school administrators who had no interest in developing a waste management program. The level of awareness is beginning to increase as a result of the recent right-to-know laws.

3.5 Laboratory Waste Minimization

Instrumentation in laboratories has increased in recent years. Instrumental analysis requires minute quantities for quantitative determinations. Chemical usage has been reduced ten to one-hundred-fold as a result. In chemistry, Nuclear Magnetic Resonance (NMR) analysis requires a 1 ml aliquot for

TABLE 3-2: HIGH SCHOOL COURSE HAZARDOUS WASTE GENERATION

<u>Courses Likely to Generate Hazardous Waste</u>	<u>Percentage of Schools Offering Courses</u>		<u>Types of Wastes That Are Potentially Hazardous</u>
	<u>1983 a/</u>	<u>1982 b/</u>	
AGRICULTURAL ARTS:			
Agriculture	29.7	48.4	Pesticides, fertilizers
Horticulture/Landscaping	1.6	23.4	Pesticides, fertilizers
GRAPHIC ARTS:			
Art	74.0	89.6	Oil-based paints, solvents
Graphics	6.0	33.3	Inks, solvents, acids
Jewelery and Metalwork	6.9	9.8	Acids
Pottery and Ceramics	16.2	28.8	Metals in glazes, silica in clays
Painting/Drawing/Design	19.6	36.0	Oil-based paints, inks, solvents
Photo/Film Making	6.4	14.1	Silver, developing and fixing chemicals
INDUSTRIAL ARTS:			
	75.5	90.6	
Carpentry/Woodworking	46.1	70.3	Stains, solvents, wood preservatives
Leather/Textiles/Upholstery	2.1	6.9	Dyes
Plastics	4.1	4.8	Ketones
Photography	5.5		Silver, Photochemicals, inks and solvents
Printing/Photo/Graphics			
Metalworking/Foundry	33.8	41.7	Metal dust
Welding	9.0	31.7	Lead solder
Auto Mechanics	18.3	47.5	Degreasing solvents, oil, grease
Power/Auto Mechanics	17.6	33.1	
SCIENCE COURSES:			
Natural Science	89.3	99.7	Various chemicals, acids, bases
Biology	79.9	97.8	
Chemistry	88.1	89.4	

TABLE 3-2: HIGH SCHOOL COURSE HAZARDOUS WASTE GENERATION (cont)

Courses Likely to Generate Hazardous Waste	Percentage of Schools Offering Courses		Types of Wastes That Are Potentially Hazardous
	1983 a/	1982 b/	
VOCATIONAL COURSES:			
Trades and Industry	24.0	94.0	
Graphic Arts	3.1	3.2	Inks, solvents
Printing/Lithography	1.9	10.3	
Textile/Leather Products	1.3	10.3	Dyes
Body and Fender Mechanics	4.4	17.9	Batteries, paints,
Automobile Mechanics	12.5	11.7	degreasing solvents, oil,grease, acids, alkaline waste
Masonry	2.5	9.5	Paint, solvents, muriatic acid
Carpentry	6.4		Stains, solvents, paints,
Woodworking 1st year	4.0		wood preservatives
Woodworking-Advanced	3.9	4.3	
Machine Shop	7.0	17.7	Stripping and cleaning
Sheet Metal	1.8	0.1	solutions, plating bath
Metalworking	1.2	0.7	residues, acids, bases,
Welding and Cutting	5.7		metal dust
Cosmetology	5.1	18.5	Various chemicals
HEALTH COURSES:			
Allied Health		20.6	Various chemicals and
Laboratory/Chemical Technology		4.5	pharmaceuticals
Nursing		11.7	

a/ Based on survey of 7,850 out of 15,306 schools

b/ Based on survey of 941 out of 15,667 schools

Source: A Trend of High School Offerings and Enrollment: 1972-1973 and
1981-1982, Evaluation Tech. Inc. under contract 300-83-0114 with DOE.

quantitative analysis. Entire chemical reactions can be performed in an NMR tube which holds under 5 ml of reactants/products. Other common instrumentation used are chromatography (gas, high pressure liquid, thin layer, other types), mass spectrophotometry, atomic absorption, IR and UV spectrophotometers, polarography, magnetic balances and others.

Using smaller volume of chemicals in teaching laboratories has reduced waste generation. Five years ago at the university undergraduate laboratory experiments were performed using 50 to 500 ml of reactants. Last year volumes were reduced to the 10 to 100 ml. This year the experiments will use 1 to 10 ml. At the college all experiments are performed with one fourth the volume stated in the laboratory manuals.

Professor Dana at Bowdoin College, Brunswick, Maine, has developed a microscale organic laboratory course. Students perform laboratory experiments using one hundredth to one thousandth the volume of starting material typically used. Using such small volumes has the following advantages: reduction in chemical usage and waste generation, decreased hazard of fire and explosion, and reduced concentration of harmful organic vapors in laboratory air (13).

3.6 Federally Funded Laboratories

Two federally funded research laboratories, Lawrence Livermore National Laboratory (LLNL) in Livermore, California and Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee have extensive waste minimization programs. At LLNL an extensive study completed by Bechtel (5) will be used to establish waste minimization programs for the four largest hazardous waste generators: plating shops, experimental circuit board, nuclear chemistry, and general plant. At ORNL, an institution-wide program has been implemented which commits ORNL management to "the reduction of hazardous waste generation and minimization of generated waste to reduce impacts on human health and the environment." Economically practical waste minimization techniques including waste abatement, recycling, good housekeeping, and in-plant treatment are being implemented (4).

ORNL, during 1983-84, generated 200,000 pounds of hazardous waste each year. To reduce this total, the Hazardous Waste

Minimization Program includes the following components (4):

- Identify all waste streams, review and make recommendations for procedural modifications, provide incentive mechanisms for new ideas/procedures, and information exchange;
- Establish effective planning and procurement practices;
- Set goals to meet quantitative reduction levels;
- Establish a baseline with which to compare waste minimization progress;
- Prioritize possible waste treatment options according to cost and environmental problems;
- Develop waste reduction/elimination plans for each wastestream;
- Assess economic, technical, and regulatory feasibility of plans; and
- Implement those plans that meet cost/benefit goals.

This ORNL Program has been effective in achieving its goals.

3.7 Purpose of Study

This study investigated hazardous waste generation and waste reduction opportunities at educational and research institutions. Waste reduction opportunities were investigated for the diverse waste streams generated. Source reduction included substitution, process changes, elimination; recycling; recovery and treatment. Waste reduction opportunities are presented in Chapter 4.

This study also developed a self-audit format that is applicable to large universities, small colleges, high schools, vocational schools and research institutions. After completing the audit, school administrators will be able to implement effective waste reduction alternatives. This audit format is in Chapter 5.

3.8 Project Approach

Audits were performed at three diverse institutions. These were a small, private, liberal arts college, a large university, and a research institution. A high school was not chosen because many reduction opportunities applicable to a small college will be applicable to a high school.

Contact at each institution was with the person responsible for hazardous waste management. An initial interview obtained a broad understanding of waste generation. This information included:

- The size and scope of the existing hazardous waste management program.
- Which departments generate hazardous waste.
- What different waste streams are generated.
- What records are maintained on waste disposal.
- Problems associated with waste collection.
- An understanding of how committed the school administration is to proper waste management.
- The amount of cooperation given by generators to proper segregation, collection, labeling, and storage of hazardous waste.

Meetings were held at each campus with department chairpersons, management services officers, chemical stockroom clerks, professors, maintenance personnel, and administrators. Inspections were made of laboratories, chemical storerooms, other areas where chemicals were used, and waste collection areas.

Prior to each meeting, detailed questionnaires were prepared to obtain relevant information. Some of these questionnaires can be found in Appendices A, B, and C.

A computer search of scientific journals provided additional information. The search identified four useful articles. The American Chemical Society (ACS) provided information for

this study. A chemistry professor at a nearby state college chaired the ACS committee on chemical safety and RCRA. He provided us with valuable insights on waste reduction opportunities.

Information from waste manifest forms was obtained from all three campuses. Data from the manifests was entered onto computer spreadsheets. This data generated tables and graphs presented in Appendices A, B, and C. These tables and graphs provide:

- Types of waste streams generated
- Quantity of each waste stream generated
- Lab pack vs. bulk generation (3 year period)
- Typical chemicals found in each waste category
- 3-year trends for quantities generated of each hazardous waste stream category

From the above information sources waste reduction options were developed. Many options are already being practiced by one or more of the audited schools. Others were developed by analysis of data and suggestions given by interviewees. A self-audit was developed to assist administrators in determining how and where these waste reduction opportunities can be implemented.

3.9 Limitation of Study

The present study included three types of colleges: a large university, a technical research institute and a small, private, liberal arts college. These represent a wide spectrum of educational institutions in California. The following types of institutions were not included in this study:

- high schools
- vocational schools
- federal research laboratories
- specialty colleges (i.e. marine biology institutes)

- medium sized liberal arts colleges

Audits were not conducted at the above types of institutions. However, the waste reduction opportunities and self-audits developed are applicable to these institutions.

Another limitation was the processes studied. Because hundreds or thousands of chemicals are used and a vast number of experiments are performed, all waste generating process could not be evaluated. Instead we focused on general categories of chemicals used and experiments performed. Certain specific experiments were evaluated. From this general and specific data, waste reduction opportunities were derived.

CHAPTER 4

WASTE REDUCTION ALTERNATIVES AND STRATEGIES

4.1 Introduction

Numerous waste reduction opportunities are available to educational/research institutions. Since most waste generation comes from laboratories, the majority of reduction opportunities listed below are for laboratories. Many recommendations are more applicable to teaching laboratories than research laboratories. Research experiments are less flexible because they are highly focused, which prohibits substitution, process change, and volume reduction.

In addition to developing waste reduction opportunities audited institutions expressed the need to amend certain environmental laws. These legislative recommendations are also listed below.

4.2 Waste Reduction Opportunities for Laboratories

4.2.1 Reagent Chemical Purchases

- A centralized purchasing program should be established. This program should monitor requests for chemicals, and implement policies. These policies would include staggered deliveries, sharing of chemicals between common users, arranging with instructors and investigators to purchase part of their request if the quantities seem excessive, and arrange for partial shipment with the remainder shipped on an as-needed basis (17). The program should include plans for leftover chemicals.
- Order reagent chemicals in exact amounts to be used. Do not order extra chemical quantities to take advantage of unit cost savings. The net savings will be lost due to eventual disposal costs if the chemical is not used (2).

4.2.2 Chemical Inventory Control

- Establish an inventory control program which can trace chemical usage from cradle to grave. This will promote sharing of chemicals between common users, provide data on who is using extremely hazardous chemicals, identify who the high volume users are, locate where caches of

unused reagents are, and delineate where waste reduction options need to be implemented. Reagent chemicals having remaining shelf-life can be monitored for approaching expiration. The inventory can be computerized or kept on a card filing system.

- Rotate chemical stocks using chemicals before their shelf life expires (first-in-first-out stock usage).
- Develop a running inventory of unused reagent chemicals for use by other laboratories or faculty.
- The inventory control program should extend to all laboratories, including that of individual professors.

4.2.3 Chemical Usage and Laboratory Activity

- Reduce the volume of chemicals used in experiments. This can be accomplished by using smaller "micro glassware", or reducing the amount in existing glassware.
- Substitute less hazardous chemicals in experiments. For example: substitute sodium hypochlorite for sodium dichromate; use acetonitrile or alcohol for benzene; substitute cyclohexane for carbon tetrachloride in the standard qualitative test for halide ions; stearic acid can replace acetamide in phase change and freezing point depression experiments; and use dichloromethane instead of carbon tetrachloride and/or chloroform.
- Use instrumental methods instead of wet chemistry procedures. Instrumental analysis requires minute quantities of chemicals as compared to wet chemistry procedures.
- Off-site analytical services may be applicable for some research projects. Costly instrumental methods may not be economical on-site, while being available off-site for determining inorganics, common organics, and standardized analyses.
- In physical chemistry use magnetic balances (Gouy Balances) instead of balances using heavy metals to reduce heavy metal usage.
- Pre-weigh chemicals for undergraduate usage. This will reduce spills and other wastes generated by students

performing their own weighing. It will also increase laboratory productivity by reducing lab time per student.

4.2.4 Laboratory Cleanup

- Use disposable plastic glassware where feasible to reduce the need to wash glassware with chromic acid. The used plastic containers would require rinsing prior to disposal.
- For cleaning laboratory glassware, substitute specialty detergents for the sulfuric acid/chromic acid cleaning solutions.
- When cleaning with solvents reuse the spent solvent for the initial cleaning and use fresh solvent only for the final rinsing. This reuse will decrease the amount of reagent solvent used (17).

4.2.5 Waste Chemical Recycling

- Segregate solvents in a closed top drum and recycle.
- Distill and reuse solvents for classroom experiments or as thinners and degreasers by the maintenance department. Low cost solvent stills are available in a variety of sizes, including high quality fractional distillation units. (17). Check with fire and worker safety regulations regarding use of on-site solvent distillation.
- Platinum, palladium, and rhodium contained in catalysts can be recovered using chemical procedures specific to the particular metals. Segregation of these wastes for off-site recycling may be preferable.
- Investigate if unused reagent chemicals and their containers can be returned to the manufacturer. Sealed bottles of stable chemicals may be resaleable by the supplier.

4.2.6 Waste Chemical Management

- Destroy wastes as the final step in experiments. This will reduce the need for off-site disposal. If done in undergraduate laboratories it will develop in students

an awareness of proper waste management and waste reduction. Numerous chemical wastes can be destroyed as a final step in experiments. See Reference 9, Prudent Practices for Disposal of Chemicals from Laboratories, National Research Council, 1983; Chapter 6.

- Provide a designated facility for waste storage, segregation and treatment. This area should be ventilated, contain a safety shower and eye wash, have sealed bermed floors and an emergency telephone.

4.2.7 Waste Reduction Program

- Appoint or hire a safety/waste management officer for each department, or for the entire school if it is a small institution. Centralizing waste management into one position will facilitate a coordinated and efficient implementation of regulations, institution policy and waste reduction goals. The officer should develop a waste reduction training program for faculty, students, and staff.
- Educate professors, students and staff on the benefits of waste reduction. This should include instruction on specific techniques for reducing waste generation.
- Establish annual goals for institution-wide and departmental for waste reduction. First determine past yearly totals of waste generation, then assess economic and technical feasibility for establishing and achieving specific reduction goals.
- Provide routine self-audits for laboratories of professors, students, and staff to minimize reagent accumulation and maximize recycling.

4.3 Waste Reduction Opportunities Outside Laboratories

4.3.1 Hazardous Material Purchase

- In art departments and maintenance substitute water-based paints for oil-based paints.
- Use less hazardous solvent degreasers. Biodegradable water-based cleaners can often be used in place of chlorinated solvents (17).

- Standardize oils and if possible. Use one type of oil for different kinds of machinery (17).

4.3.2 Hazardous Material Usage Reduction

- Only degrease parts which must be cleaned. Do not routinely degrease all parts.
- Conserve solvent in cleaning operations by using dirty solvent for initial cleaning and fresh solvent for final rinse.
- Cover the vapor degreasing unit to reduce loss of solvent to the atmosphere. Rotating parts before removal from the vapor degreaser allows condensed solvent to return to the degreasing unit (17).
- Modify spray-painting techniques to reduce paint waste. Set the correct air pressure for the spray gun and use the following stroking technique: 1) overlap the spray pattern by 50%, 2) maintain a distance of 6 to 8 inches from the workpiece, 3) hold the gun perpendicular to the surface, and 4) trigger the gun at the beginning and end of each stroke. (17).
- Investigate the use of irrigation injection of pesticides through the sprinkler system (with back flow protection), or the use of dry pesticides that are spread on the grounds and watered into the ground. This practice will eliminate the need for pesticide spraying operations and the resulting contaminated washwater.

4.3.3 Hazardous Materials Recycling

- In metal-cutting operations recycle oil until consumed. (17).
- Spent degreasing solvents can be recycled on site using small batch stills. Contractual agreements can be entered into with companies that supply fresh solvents and remove and recover the usable fraction of spent solvents.
- Photographic processes should have a silver recovery unit for recovery of silver from the waste stream.

- After pesticide application recycle the contaminated rinsewater used to clean the applicator tank by reusing it for makeup of subsequent spray solutions.

4.4 Legislative Recommendations of the Audited Institutions

The audited institutions expressed the need for modifications to existing environmental statutes. The following legislative recommendations were offered by the educational/research institutions.

- Establish "Amnesty Days" once a month when Department of Transportation rules would be suspended for schools and colleges. This would allow transportation of surplus chemicals between schools and colleges. Minnesota currently has "Amnesty Days" which has reduced the quantity of surplus chemicals requiring lab pack disposal by schools and colleges.
- Reduce permit requirements for on-site burning of high BTU value solvents in institution furnaces. Small quantities of nonhalogenated solvents can be safely burned by atomizing the solvents into the furnace at controlled rates.
- Reduce permit requirements for on-site treatment/destruction of certain chemical waste streams generated in laboratories.
- Reduce recordkeeping and waste identification requirements to simplify paperwork.

The Department of Health Services regulatory staff had the following comments about the institutions' recommendations.

- Burning of hazardous waste is generally allowed only under permit because burning constitutes treatment, which requires a permit. Reasons for permitting include presence of contaminants in the waste that might be health hazards, the generation of ash residues that might be hazardous wastes, and making sure proper operating parameters are maintained.
- Transportation of surplus reagent chemicals is not re-

stricted under hazardous waste control statutes or regulations, provided that the reagents are still usable for their original intended purposes and are being transported for that reason. Other regulations that pertain to transportation of hazardous materials might still apply, particularly U.S. Department of Transportation packaging requirements.

- Recordkeeping of hazardous waste management is generally required to maintain governmental "cradle-to-grave" control over the waste. Unused chemicals are exempt from this recordkeeping.

CHAPTER 5

WASTE REDUCTION SELF AUDIT

5.1 AUDIT DESCRIPTION

Many waste reduction opportunities can be utilized by educational/research institutions. The following WASTE REDUCTION SELF AUDIT can assist schools, colleges, and other institutions in implementing opportunities for reducing the volume and toxicity of chemical wastes generated.

Most campuses use hundreds or thousands of different chemicals. It is not necessary to identify each waste generating process or experiment to complete the audit. It is more important to identify categories and general origins of each waste stream. Certain specific waste generating processes may need to be identified and quantified.

The self audit starts with the institution and then branches into specific departments. The audit includes fill-in questions, tables, and flow diagrams. After completing this audit and implementing the audit findings, significant reductions in the quantity and toxicity of chemical wastes generated can be achieved.

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5.2 General Information

Institution _____

1. Background:

Person Completing Form _____

Title _____

Type of Institution _____

Number of Total Students _____

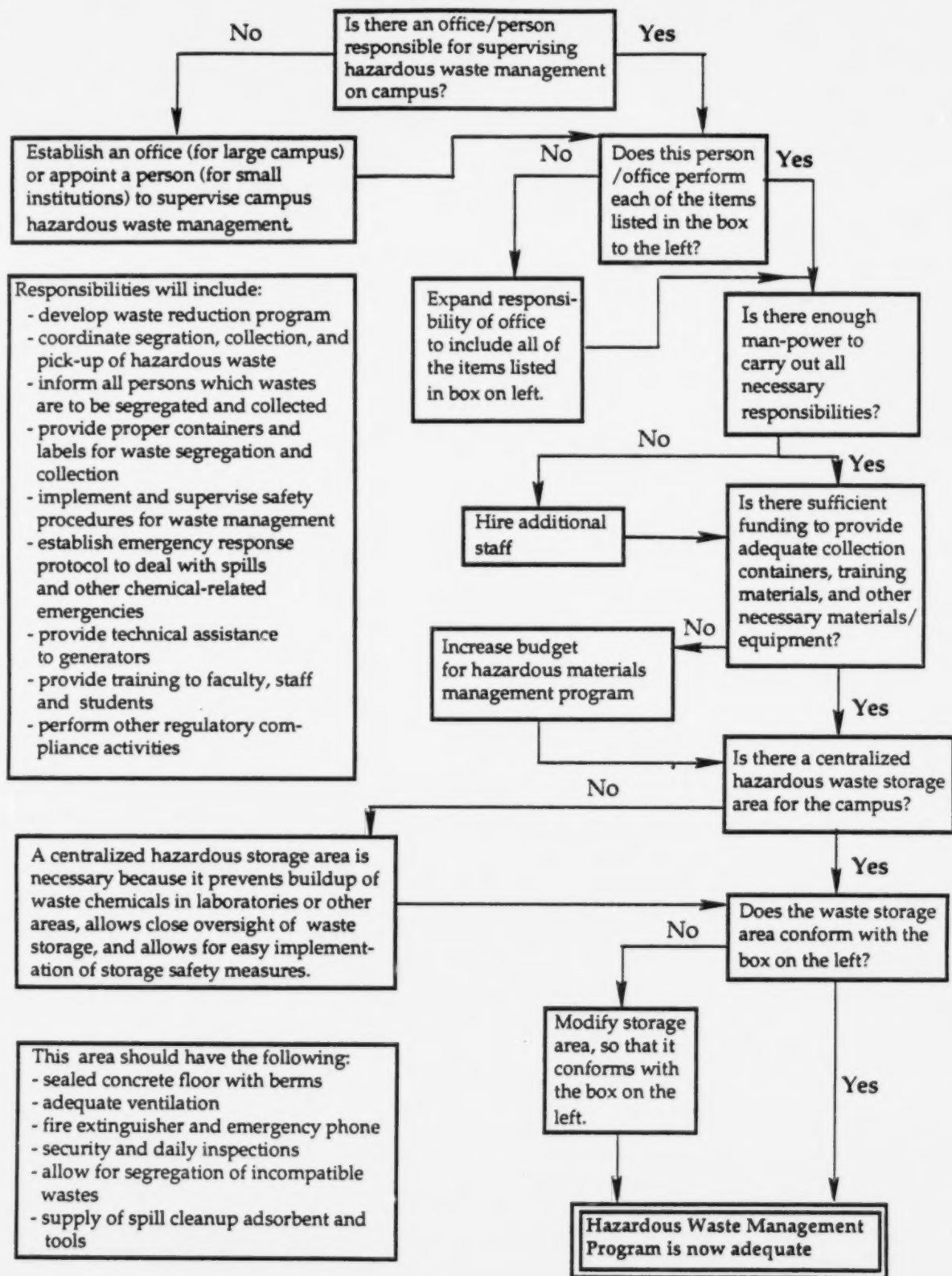
Number of Graduate Students _____

Number of Teachers/Professors _____

5.3 Hazardous Waste Management Program

Review the existing hazardous waste management system as outlined in the decision tree diagram on the following page. Identify any changes needed in hazardous waste management practices.

**FIGURE 5-1
HAZARDOUS WASTE MANAGEMENT
DECISION TREE DIAGRAM**



5.4 Waste Generation Questionnaire

- a) Is there data available on quantities of hazardous waste generated for the entire campus? Yes _____ No _____
Data Sources _____
- b) Is there data available on quantities of hazardous waste generated for each department? Yes _____ No _____
Having this type of data is important for the following reasons:
- the data defines the scope of waste generation for the entire campus and for each department
 - realistic waste reduction goals can be established (see discussion 5.4 (d) below)
 - determination of which specific generators should be targeted for waste reduction
 - determine costs for proper waste management
- c) IF Answer is No: If the answer to questions 5.4 (a) and/or (b) is No, it is recommended that methods for quantifying the waste generated for the entire campus and for each department be implemented. If adequate waste generation data is not available, establish an internal manifest system to be completed by each waste generator. An example of an internal manifest can be found in Figure 5-2. These forms should be kept on file and if possible, stored on a computer data base. Quarterly and yearly totals for hazardous waste generation can easily be determined using these manifests.
- d) IF Answer is Yes: If the answer to questions 5.4 (a) and (b) is Yes establish campus-wide and departmental waste reduction goals. Setting specific goals provides an incentive to meet established goals. A central committee should establish goals. The committee should be made up of personnel from the campus environmental/safety office, administration, and professors/instructors from each waste generating department. Reduction goals should range from a 3% to 10% per year. The committee should meet quarterly to assess progress in achieving goals.

This approach that establishes waste reduction goals has proven effective at large research facilities and at industrial research and development laboratories.

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FIGURE 5-2

INTERNAL HAZARDOUS WASTE MANIFEST

Complete all information requested below. Do not leave any space or column empty (except Other Comments column)

Department _____

Person Completing Manifest _____ Phone Number _____

Date Generated	Chemical	Quantity	Gas, Liq. Solid	Hazard	Other Comments
-------------------	----------	----------	--------------------	--------	-------------------

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.

Contact the campus Hazardous Waste Coordinator at _____ when manifest is completed and/or wastes need to be picked up.

5.5 Laboratory Audit Questionnaire

This section is to be completed by the chemistry, biology, geology, physiology, physics, and any other departments that use chemicals in laboratories.

5.5.1 Waste Management Practices Information Checklist

Each question below is to be completed for each department:

- 1) Total Number of Laboratories in Department_____.
- 2) Number of Research Laboratories_____.
- 3) Number of Undergraduate Teaching Laboratories_____.
- 4) Number of Chemical Storage (Stock) Rooms_____.
- 5) Department Person in Charge of Chemical Storage/Stock Rooms_____.
- 6) Chairman of the Department_____.
- 7) Number of Professors in the Department_____.
- 8) Subdivisions within the Department (i.e. for chemistry department: general chemistry, organic chemistry, analytical chemistry, etc.)

- 9) Rank the subdivisions from highest to lowest for quantity of waste generated.

- 10) How are chemicals purchased within the Department?_____

- 11) Is there an oversight mechanism capable of monitoring all purchases of chemicals?_____

- 12) Describe the current method of maintaining an active inventory of chemicals in stock._____

13) Who in the department maintains Material Safety Data Sheet (MSDS) files? _____

14) How are wastes currently collected for disposal within the Department? _____

NOTE: If you have trouble answering any of the above questions, investigate to find the answers. The answers will assist implementing waste reduction opportunities.

5.5.2 Science Departments Waste Reduction Checklist

The following checklist should be completed by each professor/instructor who supervises student laboratory exercises, supervises a research laboratory, or any staff person involved with handling chemicals including chemical stockroom supervisor, solutions preparation, technical supervision.

Department _____

Name of Person Completing This Checklist _____ Title _____

Waste Reduction Options Checklist

Yes No N/A

5.5.2.1 Reagent Chemical Purchase

Is it possible to increase the amount of sharing of chemicals between research laboratories? This would reduce the amount of surplus chemicals that require disposal.

Since a significant portion of laboratory waste is actually surplus reagent chemicals, is it possible to purchase smaller quantities of reagent chemicals? This would reduce generation of surplus reagent chemical waste.

5.5.2.2 Chemical Inventory Control

Instrumental methods use significantly smaller quantities of chemicals than wet chemistry methods. Is it possible to increase the use of instrumental analyses for selected experiments?

Yes No N/A

5.5.2.3 Chemical Usage and Laboratory Activity

Is it possible to reduce the volumes of reactants used in certain laboratory experiments without affecting the desired results?

Is it possible to substitute less hazardous chemicals in certain laboratory experiments such as: using sodium hypochloride for sodium dichromate, use alcohols instead of benzene, use cyclohexane for carbon tetrachloride, use stearic acid for acetoamide, and any other potential substitutes?

In physical chemistry can Gouy Balances be used instead of other standard balances? This would to reduce the amount of heavy metal needed.

For certain undergraduate laboratory exercises, is it possible to pre-weigh chemical reactants for students? This would eliminate chemical waste due to student spillage during weighing and transfer operations.

5.5.2.4 Laboratory Cleanup

To reduce the amount of chromic acid wash to clean glassware, is it possible to use disposable plastic glassware that would not require cleaning? The waste classification of the disposed plastic must be considered.

Is it possible to substitute specialty detergents for chromic/sulfuric acid for cleaning glassware?

If solvents are used for cleaning, is counter current cleaning possible? This uses the used solvent for initial cleaning and fresh solvent only for the final cleaning. This decreases the amount of reagent solvent used.

Is a solvent sink being used? If not, could one be used?

5.5.2.5 Waste Chemical Recycling

Yes No N/A

Can solvent waste be redistilled and reused for class-room experiments or as thinners or degreasers by the maintenance department. Redistilling could also be accomplished by purchasing a bench-top solvent recovery unit. If onsite solvent distillation is done, does it comply with fire and worker safety regulations?

5.5.2.6 Waste Chemical Management

Can waste chemicals be destroyed as the final step of selected laboratory classwork and research experiments? (Reference (9) Chapter 6 describes destruction procedures for experiment wastes).

Are there any other waste reduction suggestions or options available that are not mentioned above?

5.6 Art, Theater Arts, Scenery Shop and Printing Waste Reduction Check List

Yes No N/A

5.6.1 Hazardous Material Purchase

Is it possible to significantly reduce or eliminate use of oil-based paints?

Many photo processor cleaning chemicals are very hazardous (i.e. chromic acid). Is it possible to substitute less hazardous cleaning compounds?

Many hazardous chemicals are used in art department subdivisions including silk screening, metal work, and sculpture. Is it possible to reduce or substitute for use of specific hazardous chemicals in any of these areas?

5.6.2 Hazardous Material Usage Reduction

Yes No N/A

When spray painting, is it possible to use the following techniques to reduce the amount of paint used?

- overlap the spraying pattern by 50%
- maintain a distance of 6 to 8 inches from the work piece
- hold the gun perpendicular to the surface
- trigger the gun at the beginning and end of each stroke?

5.6.3 Hazardous Materials Recycling

In photographic processing is there currently a silver recovery unit in place to recover silver salts in the waste water?

If there is no silver recovery unit, is it possible to install one?

Is off-site recovery feasible?

In pottery making or other related work, is it possible to eliminate use of lead glazes?

5.7 Maintenance Machine Shop Waste Reduction Checklist

This checklist should be presented to maintenance and machine shop supervisors for their review.

Yes No N/A

5.7.1 Hazardous Materials Purchase

Is it possible to eliminate use of oil based paints and replace with water based paints?

Is it possible to standardize oils used for many kinds of machinery?

Can hazardous solvent degreasers be replaced by alkaline degreasers or less hazardous solvent degreasers?

5.7.2 Hazardous Material Usage Reduction

For metal cutting operations can oils be recycled without treatment until completely consumed?

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	<u>Yes</u>	<u>No</u>	<u>N/A</u>
If a vapor degreasing unit is used, is it possible to keep it covered when not in use to reduce loss of solvent to the atmosphere?	_____	_____	_____
When using a vapor degreasing unit, is it possible to rotate parts above the unit before removal to allow condensed solvent to return to the degreasing unit?	_____	_____	_____
Is it possible to restrict the number of parts that must be degreased to only those parts that badly need degreasing rather than routinely degreasing all parts?	_____	_____	_____
To conserve use of reagent solvents, can dirty solvent be used for initial cleaning, and fresh solvent used for final cleaning?	_____	_____	_____
Is a solvent sink being used? If not, could one be used?	_____	_____	_____
Is a bench-top still appropriate? If one is being used does it comply with fire and worker safety regulations?	_____	_____	_____
When spray painting, is it possible to use the following techniques to reduce the amount of paint used?			
- overlap the spraying pattern by 50%			
- maintain a distance of 6 to 8 inches from the work piece			
- hold the gun perpendicular to the surface			
- trigger the gun at the beginning and end of each stroke?	_____	_____	_____

5.8 Grounds Maintenance Operation Waste Reduction Checklist

5.8.1 Waste Reduction Option

	<u>Yes</u>	<u>No</u>	<u>N/A</u>
For pesticide spraying equipment, can the generation of contaminated rinse water contaminated with pesticides be reduced or eliminated? This can be done by saving and using the rinse water for makeup of the next pesticide application solution.	_____	_____	_____
To reduce or eliminate the need for spraying pesticides can either of the following be implemented:			
- irrigation injection where the pesticide formulation is injected directly into the sprinkler/irrigation			

	<u>Yes</u>	<u>No</u>	<u>N/A</u>
system at a controlled rate and with adequate back-flow prevention devices.	_____	_____	_____
- spread pesticides in the dry powder form and then water then into the ground	_____	_____	_____

* * * * *

5.9 Application of Checklist Results

Use this checklist to implement waste reduction options that were marked "YES." For items marked "NO" further investigation should be conducted to determine why the particular option cannot be utilized. If technical assistance is required for implementing waste reduction options, see REFERENCES, or contact Department of Health Services, Alternative Technology Office at (916)324-1807.

CHAPTER 6

STATUTES AND REGULATIONS AFFECTING HAZARDOUS WASTE GENERATORS

6.1 Introduction

California generators, transporters and storage facilities must comply with state laws for handling hazardous materials and wastes. The California Department of Health Services is the state agency responsible for controlling and monitoring hazardous waste management. This chapter will discuss state laws that apply to educational and research institutions that generate, treat, store, and/or dispose of hazardous waste.

6.2 Generator Standards

Article 6, Chapter 30, Division 4, Title 22, California Code of Regulations (CCR) details requirements with which all generators of hazardous waste must comply. These requirements are described below.

6.2.1 Determination of Waste Classification

The generator of a waste must determine if the waste is hazardous. To do this the generator must determine if the waste is specifically listed as a hazardous waste (Article 9, CCR), and/or if it is a characteristic hazardous waste (ignitable, corrosive, toxic, reactive) (Article 11, CCR). Certain wastes are also classified as "extremely hazardous wastes." These are listed in Article 9, CCR and their characteristics are identified in Article 11, CCR.

6.2.2 Generator Requirements

Educational institutions that generate hazardous waste must fulfill the following requirements:

- Determine if each generated waste is hazardous.
- Obtain an EPA Identification Number.
- Prepare a manifest form for all off-site shipments of hazardous waste.
- Prepare and submit biennial reports covering generator

activities of the previous year with respect to hazardous waste.

- Ship hazardous wastes off-site within 90 days or obtain a hazardous waste storage facility permit from DHS and comply with other requirements applicable to facility operators.
- Ensure that all wastes prior to shipment off-site follow Department of Transportation regulations for proper packaging, labeling, and marking.

The generator is responsible for meeting other requirements that may not be specified in this report.

6.2.3 EPA Identification Number For Generators

Any generator of hazardous waste must obtain from EPA or DHS an identification number. (At press time, DHS issued all numbers except numbers for generators of federally regulated hazardous wastes in quantities greater than 100kg per month). This number must be used on all official documents involving waste generation, transportation, treatment, storage, and/or disposal. This number must also appear on all required reports. A generator shall not offer his hazardous waste to a transporter or to an operator of a treatment, storage, and/or disposal facility who does not have an EPA Identification Number.

6.2.4 Hazardous Waste Manifests

A generator who offers for transportation a hazardous waste for treatment, storage and/or disposal off-site must prepare a manifest before shipping the waste off-site. The manifest is a multicopied document that allows the generator and the state to track shipments of hazardous waste. The manifest also provides the state with data on waste generation throughout the state.

The generator must designate on the manifest one facility which is permitted to handle the waste described on the manifest. Copies of the manifest must be sent to the DHS, and maintained by the generator for at least three years.

6.2.5 Reports

A generator who ships his hazardous waste off-site shall prepare and submit a biennial report to the California Department of Health Services by March 1 of each even numbered year. The report covers generator activities with respect to hazardous wastes during the previous calendar year. Another report must be sent to the State Board of Equalization for taxation purposes.

6.2.6 Packaging, Labeling and Marking Requirements for Generators

Hazardous waste must be packaged in accordance with Department of Transportation (DOT) requirements prior to shipment to a treatment, storage and/or disposal facility. Marking and labeling must also be in accordance with DOT guidelines. A hazardous waste label must be affixed to all hazardous waste containers.

6.3 Hazardous Materials/Waste Storage

The following table lists laws that apply to the storage of hazardous waste.

Table 6-1 Statutes and Regulations
Pertaining to the Storage of Hazardous
Materials And Waste

<u>Statute/Regulation</u>	<u>Description</u>
California Code of Regulations (CCR) Title 23, Chapter 3, Subchapter 16	Regulates underground storage of solvents.
California Health and Safety Code (CHSC) Division 20, Chapter 6.7	Regulates underground storage of hazardous substances.
CCR, Title 22, Division 4, Chapter 30, Article 24	Regulates the use and management of containers.
CHSC, Division 20, Chapter 6.95	Requires businesses including educational institutions, to submit hazardous ma-

	terials management plans and inventories to the local agency administering the program.
CHCS, Division 20, Chapter 6.5, Section 25123.3	Definition of storage facility
CCR, Title 22, Chapter 30, Article 6	Sets requirements for generators of hazardous wastes including restrictions on how long wastes can be accumulated without the storage facility being permitted

6.4 Recyclable Wastes

If a hazardous waste such as a spent solvent can be recycled and used on-site, it might be exempt from many of the above listed requirements, as well as from DHS permit requirements. The recycling must generally be done continuously without storing the waste prior to reclamation. The recycled material is not considered a waste. Other conditional exemptions for recycling of hazardous waste also exist (Section 25143.2, CHSC).

The DHS' regulations provide a list of recyclable hazardous wastes and suggest methods for recycling them. If a "recyclable" waste is disposed of, the DHS may require the generator to explain why the waste was not recycled. The generator must respond. (See Section 25175, CHSC and Sections 66763 and 66796, CCR).

By 1990, any hazardous waste that has greater than 3000 Btu/lb must be incinerated or go through an equivalent treatment process. Also, in 1990, hazardous wastes containing volatile organic compounds in concentrations exceeding standards to be determined by DHS must be incinerated or be disposed of by an equivalent treatment process.

6.5 "Lab Packs"

Most laboratory generated waste is disposed of in lab packs. Lab packs are steel drums containing small containers of compatible hazardous wastes. The small containers in the drum are packaged in chemical adsorbent. The drum is then sent to a hazardous waste landfill. On July 8, 1989 the following waste chemicals in lab packs will be restricted from landfills:

<u>Element/Compound</u>	<u>Concentration Limit of Restriction</u>
1. Liquid hazardous waste containing free cyanides	≥1000mg/liter
2. Liquid hazardous waste containing one or more of the following:	
Arsenic and/or arsenic compounds	≥500mg/liter
Cadmium and/or cadmium compounds	≥100mg/liter
Chromium VI and/or chromium VI compounds	≥500mg/liter
Lead and/or lead compounds	≥500mg/liter
Mercury and/or mercury compounds	≥20mg/liter
Nickel and/or nickel compounds	≥134mg/liter
Selenium and/or selenium compounds	≥100mg/liter
Thallium and/or thallium compounds	≥130mg/liter
3. Liquid hazardous waste with a pH less than or equal to 2.0	-
4. Liquid hazardous waste containing polychlorinated biphenyls (PCB)	≥50mg/liter
8. Liquid hazardous waste containing halogenated organic compounds (i.e. chlorinated solvents)	≥1000mg/kg

If a lab pack includes a hazardous waste that contains any of the above elements/compounds at or in excess of any of the limits stated above, it cannot be disposed on land on and after July 8, 1989.

6.6 Other State and Federal Statutes Rules and Regulations

There are many federal statutes and regulations requiring compliance. Many of these federal laws are the same as California laws. Some of these federal and state laws are discussed below.

6.6.1 Federal Clean Water Act

The Federal Clean Water Act (CWA) mandates the establishment of pretreatment standards for discharges to "publicly owned treatment works" (POTW). Institutions that are connected to public sewers must comply with the CWA pretreatment standards. This could result in not allowing certain compounds down the drain even if diluted (e. g. formaldehyde cannot be discharged to a POTW even in minute quantities with abundant dilution).

The CWA has also established the National Pollutant Discharge Elimination System (NPDES) program which regulates discharges to surface waters. The California State Water Resources Control Board and its 9 regional boards carry out the NPDES program in California.

6.6.2 Federal Occupational Safety and Health Act

The Federal Occupational Safety and Health Act (OSHA) and State occupational safety laws regulate chemical handling on public and private campuses. OSHA's "Right-to-Know" provision requires employers to train their employees about hazardous substances they handle. The law applies to paid employees of educational institutions, but not to students. The OSHA "Right-to-Know" provisions (and state "Right-to-Know" laws) have increased the awareness of chemical hazards in schools, and they have given impetus to the creation of hazardous waste management programs.

There is currently pending in the California Legislature a bill called the "Student-Right-To-Know" bill which would require educational institutions to develop a safety program for students who handle hazardous materials.

6.6.3 California Proposition 65

Proposition 65 requires private campuses to post warnings for persons handling carcinogenic compounds, and restricts all discharges of carcinogenic compounds. This is a new law that at present does not affect public institutions. However, state legislation is pending that will require public institutions to comply.

6.7 Contacting Government Agencies

The following is a list of some regulatory agencies that may be contacted with questions on the handling and disposal of hazardous waste:

<u>Agency</u>	<u>Telephone Number</u>
<u>Federal</u>	
U.S. Environmental Protection Agency RCRA/Superfund Hotline (information number)	(800) 424-9346
Office of Solid Waste, EPA - for information on solvent waste disposal	(202) 382-4770
<u>California</u>	
Department of Health Services Toxic Substances Control Division, regional offices	See Figure 6-1
Governor's Office of Planning and Research Office of Permit Assistance	(916) 322-4245
Regional Water Quality Control Boards	See Figure 6-2



STATE WATER RESOURCES CONTROL BOARD
P. O. Box 100, Sacramento, CA 95801

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARDS

NORTH COAST REGION (1)

1440 Guerneville Road
 Santa Rosa, CA 95403
 (707) 576-2220

SAN FRANCISCO BAY REGION (2)

1111 Jackson Street, Rm. 6040
 Oakland, CA 94607
 (415) 464-1255

CENTRAL COAST REGION (3)

1102-A Laurel Lane
 San Luis Obispo, CA 93401
 (805) 549-3147

LOS ANGELES REGION (4)

107 South Broadway, Rm. 4027
 Los Angeles, CA 90012
 (213) 620-4460

CENTRAL VALLEY REGION (5)

3443 Routier Road
 Sacramento, CA 95827-3098
 (916) 361-5600

Fresno Branch Office

3614 East Ashlan Ave.
 Fresno, CA 93726
 (209) 445-5116

Redding Branch Office

100 East Cypress Avenue
 Redding, CA 96002
 (916) 225-2045

LAHONTAN REGION (6)

2092 Lake Tahoe Boulevard
 P. O. Box 9428
 South Lake Tahoe, CA 95731
 (916) 544-3481

Victorville Branch Office

15371 Bonanza Road
 Victorville, CA 92392
 (619) 241-6583

COLORADO RIVER BASIN REGION (7)

73-271 Highway 111, Ste. 21
 Palm Desert, CA 92260
 (619) 346-7491

SANTA ANA REGION (8)

6809 Indiana Avenue, Ste. 200
 Riverside, CA 92506
 (714) 782-4130

SAN DIEGO REGION (9)

9771 Clairemont Mesa Blvd. Ste. B
 San Diego, CA 92124
 (619) 265-5114



FIGURE 6-2
CALIFORNIA REGIONAL WATER QUALITY
CONTROL BOARDS AND THE REGIONS
SERVED BY THEM



RALPH STONE AND CO., INC.
 10954 SANTA MONICA BLVD.
 LOS ANGELES, CA 90025

CHAPTER 7

WASTE AUDIT OF A LARGE UNIVERSITY

A large university was audited to determine the extent of hazardous waste generation and investigate reduction opportunities. The university has a large graduate program and teaching hospital. There are over two thousand teaching and graduate laboratories on campus.

7.1 Hazardous Waste Management Overview

A formal waste management program was in existence for five years. The program is carried out by the campus safety office. They are responsible for collection of hazardous waste, spill response, chemical safety, and other compliance activities.

The largest waste stream is organic solvents. The second largest is corrosives. The corrosive category includes organic and inorganic acids and bases. Waste oil is also generated in maintenance shops and laboratories. Approximately 50% of the total campus hazardous waste stream is unused bottles of reagent chemicals. The other 50% is mixtures, contaminated solutions and spent solvents. When professors leave the university there are usually large quantities of surplus reagents and waste chemicals left in their laboratory. University administrators estimate that by the year 2000 sixty-five percent (65%) of the professors will retire which will increase the number of these laboratory chemical cleanouts. Figure 7-1 shows the bulk versus lab pack disposal for the university. Figure 7-2 shows waste streams generated at the university.

Approximately 50% of the hazardous waste on campus is collected. When waste is generated a form is completed and sent to the safety office. Arrangements are then made for pickup and disposal. Figure 7-3 shows a copy of this form. In some departments wastes are temporarily stored in the chemical stockroom. In others the safety office picks up wastes directly from the generator. All waste ends up at a central waste storage area. In this area wastes are segregated into compatibility groups and are "lab packed" by an outside contractor. Bulk solvents received in five gallon safety cans are poured into 55 gallon drums and sent off campus for recycle, fuels blending or incineration.

TABLE 7-1: ABBREVIATIONS FOUND ON BAR DIAGRAMS

Ex = Explosives

ORM-A = Department of Transportation hazardous materials classification "Other Regulated Material-A". This category includes materials which have "an anesthetic, irritating, noxious, toxic or other similar property and which can cause extreme annoyance or discomfort to passengers and crew in the event of leakage during transportation". Typical chemicals in this category are chlorinated solvents.

ORM-B = Department of Transportation hazardous materials classification "Other Regulated Material-B". These are chemicals capable of causing significant damage to transport vehicle from leakage during transportation.

ORM-E = Department of Transportation hazardous materials classification "Other Regulated Material-E". This category includes materials that are to included in any other hazard class, but it is subject to appropriate transportation regulations. Materials in this class include hazardous materials and wastes.

OP = Organic Peroxide waste.

WR = Water Reactive waste.

FIGURE 7-1
LARGE UNIVERSITY CHEMICAL WASTE
DISPOSAL - LABPACK VS. BULK

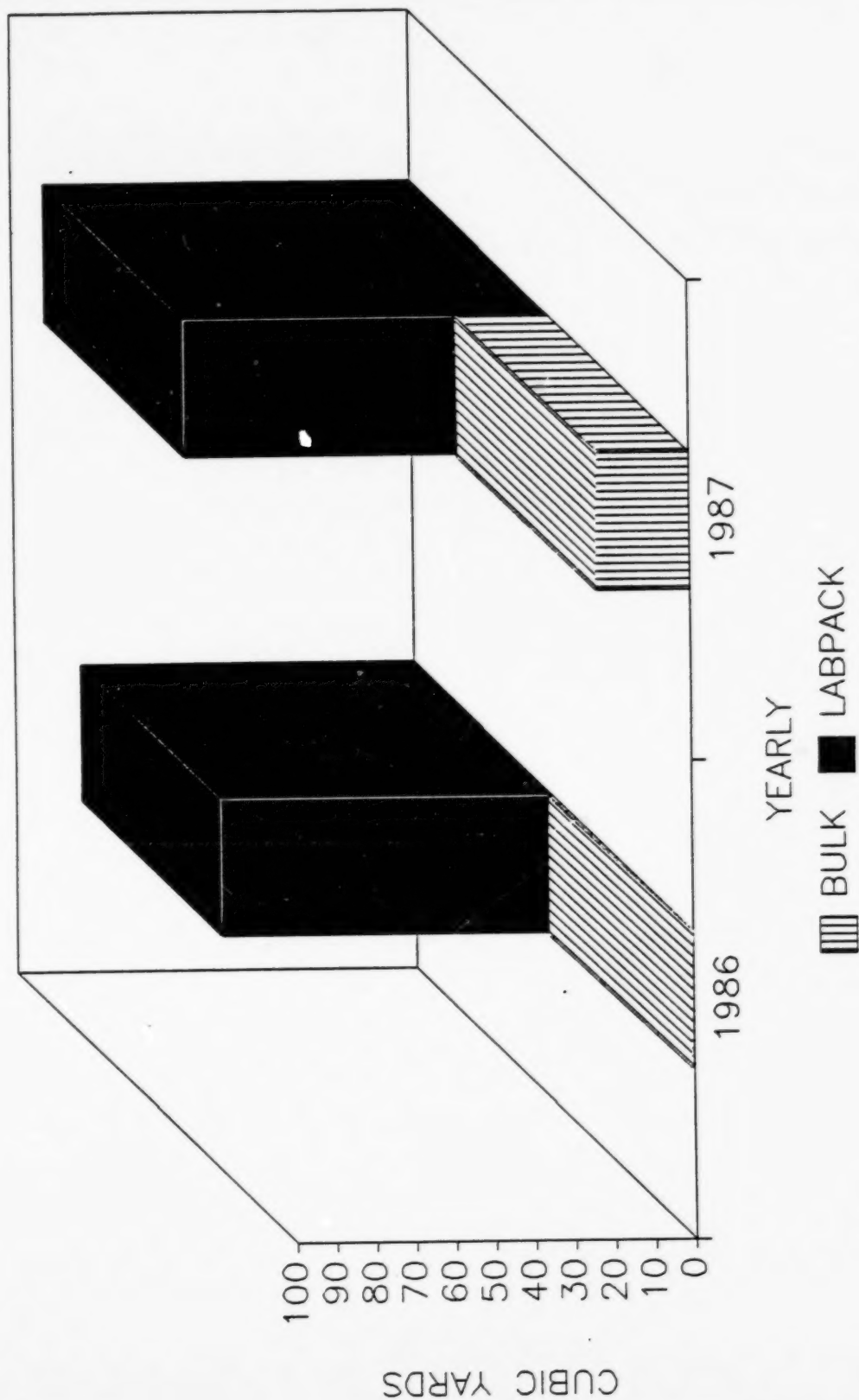


FIGURE 7-2
HAZARDOUS WASTE DISPOSAL FOR THE
LARGE UNIVERSITY

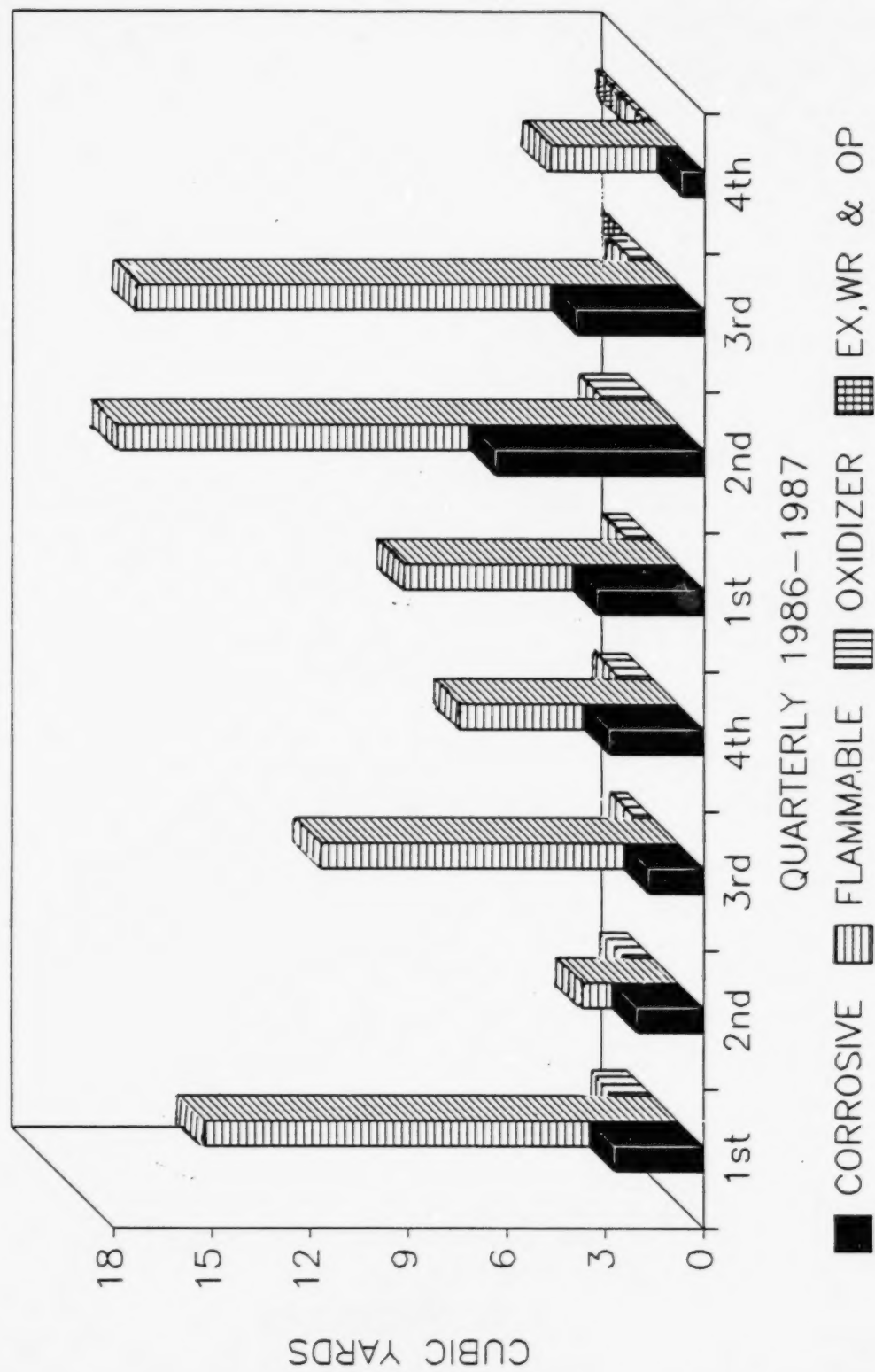
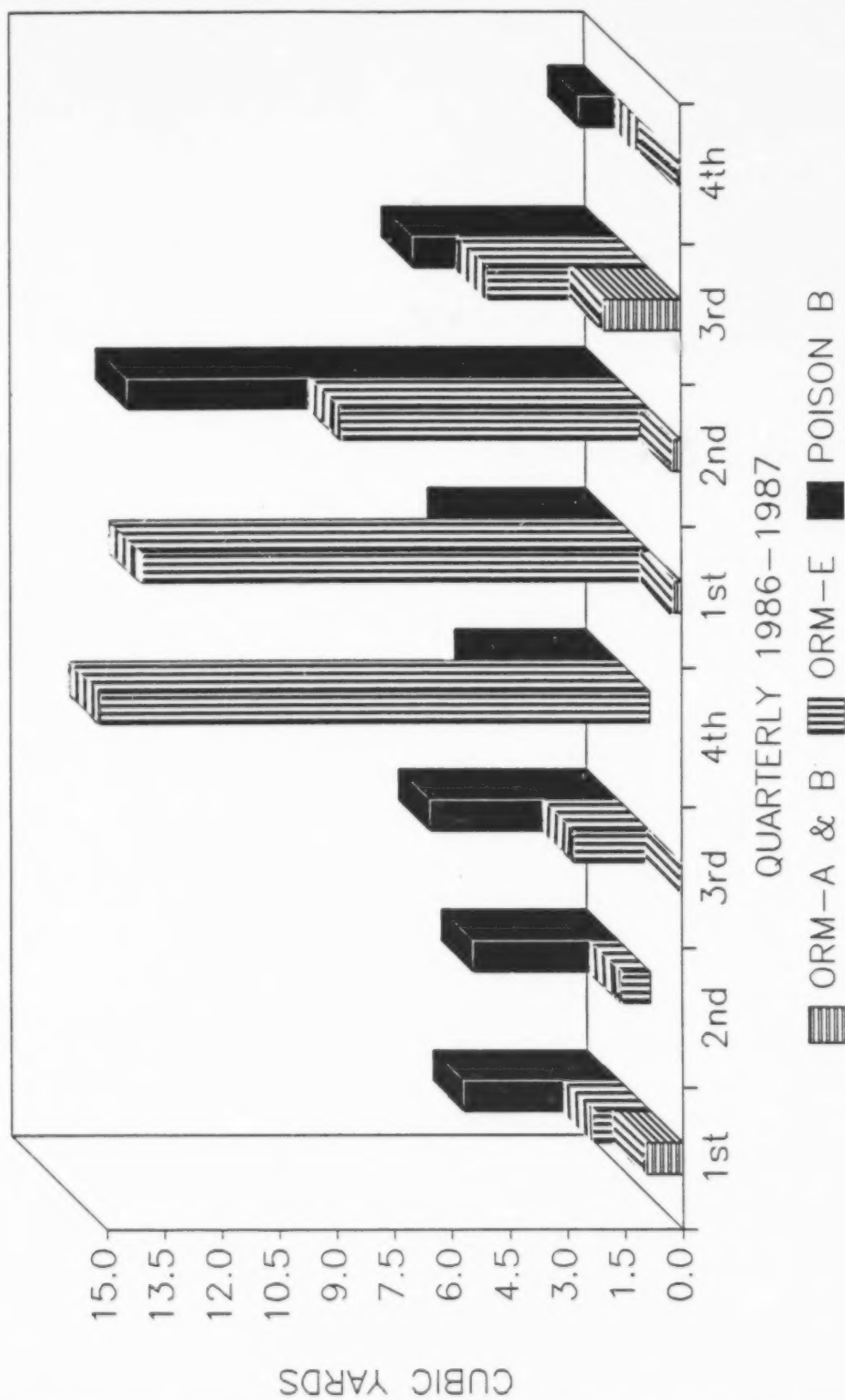


FIGURE 7-2 (CONT)
HAZARDOUS WASTE DISPOSAL FOR THE
LARGE UNIVERSITY



HAZARDOUS CHEMICALS DISPOSAL LIST

Date _____

Department _____

Person to contact regarding this list:

NAME _____

TELEPHONE NUMBER

[illegible]

7.2 Waste Sources

The largest waste generator is chemistry. Other generators of waste are biology, physics, geology, art, engineering, printing operations and maintenance. Waste generated from the teaching hospital was not included in the scope of this study.

7.2.1. Chemistry Department

The undergraduate program has six subdivisions: general, organic, inorganic, analytical, physical and biochemistry. General chemistry generates waste silver. This silver is saved for recycle. Acids and bases are neutralized and poured down the drain. All other general chemistry waste is nonhazardous. Organic chemistry waste includes halogenated and nonhalogenated solvents, and inorganic salts. Heavy metal waste is generated in inorganic chemistry. Analytical chemistry generates very little waste because of the micro scale volumes used in instrumental analysis. Physical and biochemistry generate very little waste. A breakdown of waste chemicals generated in sophomore organic chemistry and undergraduate biochemistry can be found in Appendix A. Increased environmental regulation has changed undergraduate chemistry. Use of lead and mercury has been eliminated. Physical chemistry has eliminated the use of benzene. There has been a significant increase in collection and segregation of waste chemicals. "Micro-scale" laboratory exercises are selectively being instituted throughout the department.

Professors stated the following advantages and disadvantages to full implementation of "micro scale" laboratory work:

Advantages of micro scale:

- 1) Students learn to work more carefully because of the small sizes. It helps student's improve their laboratory technique.
- 2) Significant decreases occur in chemical usage and waste generation.

Disadvantages of micro scale:

- 1) Glassware is expensive. Micro glassware kits range in cost from \$60 to \$200 per kit, depending on the quality and size of glassware desired.

- 2) Need to redesign experiments.
- 3) Certain reactions overheat and run out of control when using small quantities.
- 4) Micro scale experiments require pure grade chemicals which are expensive.
- 5) Students do not get the experience of handling and assembling large glassware.
- 6) Certain reactions require at least 50 ml to work (i.e. Grignard reaction).

The department has reduced the scale of laboratory experiments from 50 - 100 ml to 1 - 10 ml for most experiments.

Use of instrumentation in undergraduate laboratories has increased. This has reduced chemical usage 10 to 100 fold. Instruments used are gas chromatography, infrared spectrophotometry, and nuclear magnetic resonance (NMR). NMR is becoming the major method of identifying organic compounds. Wet chemistry is becoming less common.

Organic and inorganic graduate chemistry subdivisions generate the most waste. The largest waste stream is organic solvents. Quantities of chemicals used in all graduate subdivisions has decreased as a result of instrumentation. Surplus reagent chemicals from the research laboratories are added to the intracampus chemical exchange program. Research funding cutbacks have increased the efficiency of chemical usage. Three thousand different chemicals are used in the department.

A computerized chemical tracking system is used within the chemistry department. This system tracks chemicals from the time it arrives on campus to the time it is used up or until it leaves campus as a waste. A diagram depicting chemical flow in the department and where computer input occurs is shown on Figure 7-4.

7.2.2. Biology Department

The biology department has a large graduate program in addition to undergraduate studies. Undergraduate biology uses organic solvents, acids, stains, and numerous nonhazardous

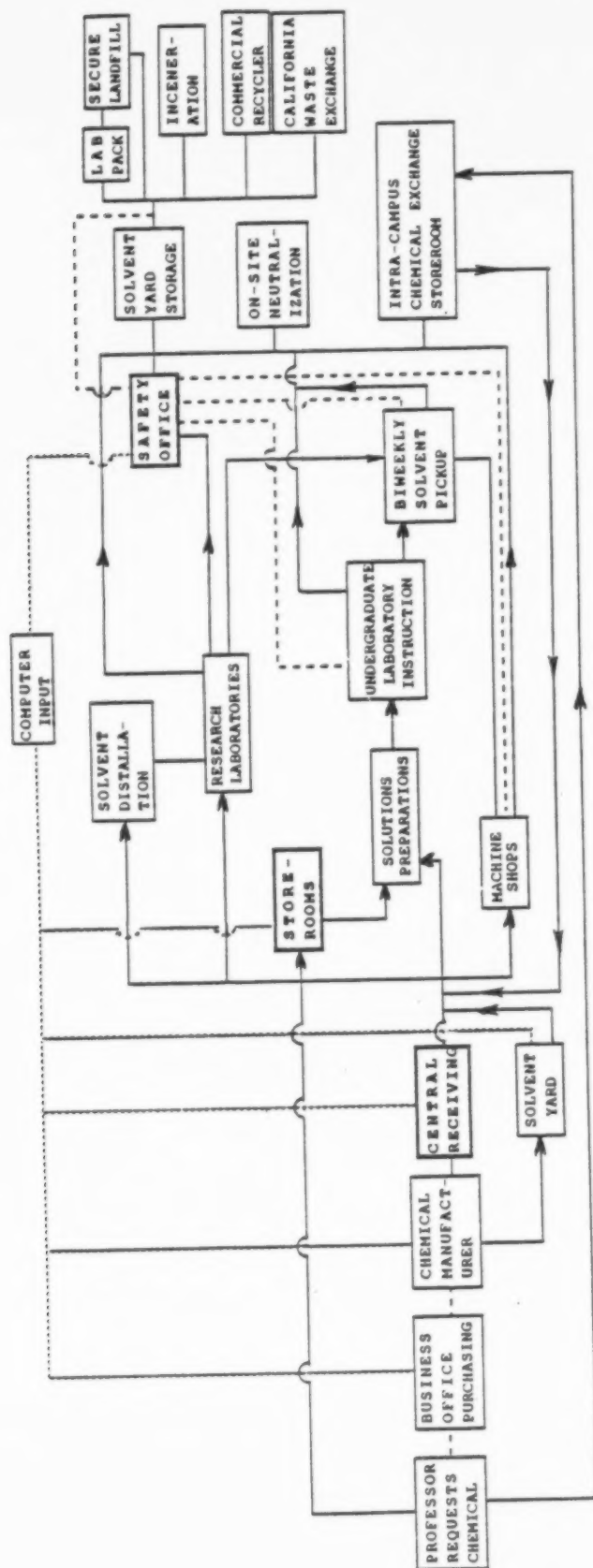


FIGURE 7-4

LARGE UNIVERSITY CHEMISTRY
DEPARTMENT CHEMICAL FLOW DIAGRAM

CHEMICAL FLOW —
PAPER FLOW - - -
COMPUTER INPUT . . .

chemicals. Many toxic chemicals have been phased out. The volume of reactants used has been reduced to the minimum required to perform experiments. The need to cut costs, and increased use of instrumentation, are promoting reduction.

The graduate division is divided into two areas: molecular and cell biology. Chemicals used and waste generated in cell biology are: organic and inorganic acids and alkalies, organic solvents, carcinogenic compounds (benzidine, diazide, and nitrogenous compounds used in assays), and small quantities of other hazardous and nonhazardous compounds.

Molecular biology uses less chemicals than cell biology. Chemicals used and wastes generated are phenol, methanol, formaldehyde, ethers, acrylonitriles, organic solvents, heavy metals, inorganic acid washes, and inorganic salts. Research is geared to DNA and protein analysis/synthesis.

Since biological research is said to be underfunded, professors are trying to cut costs. This drive toward cost effectiveness has reduced the volume of chemicals used and increased the sharing of chemicals between laboratories.

Use of instrumentation has made analytical work "micro scale". Chromatographic analysis and gel electrophoresis are two methods commonly used. There has been a two to ten fold decrease in chemical usage as a result of instrument usage.

The biology department sporadically generates 50 - 200 gallons of formalin. This waste comes from use of preserved specimens.

7.2.3 Geology, Physics, Psychology and Engineering Departments

Geology, physics, psychology and engineering each use less chemicals than chemistry and biology. Small amounts of organic solvents, acids, bases, metals, and other chemicals are used. Small quantities of waste are generated from use of these chemicals. Instrumental analysis used in these disciplines has decreased the amounts of chemicals used and the resulting waste generated.

7.2.4 Art Department

The art department uses a wide range of chemicals. Specialties that use chemicals are printing, textiles, ceramics,

painting, silk screening, sculpture and photography. Chemicals used and wastes generated from these processes are: inorganic acids, zinc, acetic acid, diesel, kerosene, turpentine, alcohols, oils, paints, and small amounts of other chemicals. There have been few, if any, substitutions of less hazardous chemicals used as a result of increased safety and environmental regulations. Only the awareness of the hazards of chemicals used has increased.

7.2.5 Theater Department

The scenery shop has eliminated use of oil-based paints and thinners. It presently uses only water based paints.

7.2.6 Maintenance Department

Maintenance functions are divided into the following specialties: electrical, painting, plumbing, hardware, sign shop, building maintenance, sheet metal, plant operations, building and grounds, custodial and fleet services. The paint shop generates waste paint, paint sludge and spent thinner. The other areas generate waste solvents and oils. Buildings and grounds avoids generation of pesticide rinse water by saving this rinse water and using it in the next spraying operation. Replacement of old polychlorinated biphenyl (PCB) transformers has created a PCB waste stream that is incinerated.

7.3 Recommendations

Waste reduction can be increased by implementing the following recommendations:

7.3.1 Laboratory Practices

- Increase dissemination of information regarding proper waste management and waste reduction to generators.
- Purchase and distribute additional 5 gallon safety cans to promote segregated collection of chlorinated and nonchlorinated solvents.
- Encourage laboratory personnel to purchase smaller volumes of chemicals. This will reduce generation of surplus reagent chemicals.
- Implement a bar coding system for chemicals used on campus to facilitate tracking of these chemicals. Advan-

tages are: increase the sharing of chemicals between common users, provide up-to-date records on inventory and ages of chemicals, and identify which labs use extremely toxic chemicals.

- In physical chemistry laboratories use magnetic balances (Gouy Balances) to reduce the volume of heavy metals needed for certain experiments.
- In undergraduate laboratories, use pre-weighed chemicals for students. This will eliminate waste generation by student spilling/mishandling chemicals. If cost-effective, pre-weighed packages could be purchased directly from the manufacturer.
- Encourage use of the intracampus chemical exchange/recycle program that is in existence.
- For biology establish a hazardous material/waste handling room. At present, there are no safe areas for storage and handling of hazardous materials and wastes. Providing such a facility would promote proper management of hazardous waste and aid in waste reduction.
- Substitute special detergents for chromic acid for washing glassware.
- In all laboratory work increase the use of micro-glassware to reduce the volume of chemicals required.
- Purchase desktop solvent recovery units to increase re-use of solvents on campus.
- Increase in-lab destruction/treatment of waste chemicals. Many toxic and corrosive waste chemicals can be converted to nonhazardous chemicals via chemical treatment (see reference "Prudent Practices for Disposal of Chemicals From Laboratories", National Research Council, 1983; Chapter 6). Waste destruction should be included as the final procedure in experiments.

7.3.2 Hazardous Waste Management Practices

- For each department appoint a hazardous waste management coordinator. This person will oversee safety, chemical

handling, waste collection, proper container use, and promotion of waste reduction.

- Establish campus and departmental goals for waste reduction. Establishing specific goals will provide an incentive for achieving these goals. They can be established as either a percent reduction or total volume reduction. Prior to establishing goals, detailed analyses of current generation rates must be performed. A campus waste reduction committee should be established. The committee should include representative departments' hazardous waste coordinators, and chairpersons, campus safety office, and a high level campus administrator. The committee function will be to establish reduction goals and oversee progress.
- For pesticide application investigate the use of irrigation injection to replace spraying operations. Use of irrigation injection will reduce the amount of pesticide and rinse waters generated. Special plumbing modifications to sprinkler systems will allow direct input of pesticides to the sprinkler system. Another alternative to spraying is applying pesticides in dry powder form and watering them into the soil.
- Provide additional staff in the safety office to assist in proper management and coordination of hazardous waste on campus.

Chapter 8

WASTE AUDIT OF A RESEARCH INSTITUTE

A research institute was audited as part of the study. Current research areas at the institute are in chemistry, biology, geology, physics, engineering, environmental science and computer science.

8.1 Hazardous Waste Management Overview

An established waste management program was in place. It is carried out by the campus health and safety office. The program includes collection of waste chemicals, spill response, and technical assistance to generators. There is a central waste chemical storage area. This area stores drums of bulk waste, chemicals to be lab packed, and chemicals intended for recycle/exchange within the institute. Figure 8-1 shows the bulk versus lab pack disposal for the institute.

8.2 Waste Sources

Data and analysis of waste streams can be found in Appendix B. There were no records available at the institute on waste generation from particular laboratories. The only records were Uniform Hazardous Waste Manifests. Asbestos and waste oil are not included in this study. Chemistry and biology departments generate the largest quantity and diversity of waste. Figure 8-2 shows waste streams generated at the institute.

8.2.1 Chemistry Department

Organic and inorganic subdivisions generate the largest quantity and diversity of waste. The other subdivisions generate small volumes. Both increased use of instrumentation and performing experiments under a vacuum have reduced chemical usage and waste generation.

There are 900 different chemicals in the department stockroom. Acetone is used at the rate of four 55 gallon drums every two months, methanol at six 55 gallon drums per year, and hexane at four 55 gallon drums per year.

TABLE 8-1: ABBREVIATIONS FOUND ON BAR DIAGRAMS

Ex = Explosives

ORM-A = Department of Transportation hazardous materials classification "Other Regulated Material-A". This category includes materials which have "an anesthetic, irritating, noxious, toxic or other similar property and which can cause extreme annoyance or discomfort to passengers and crew in the event of leakage during transportation". Typical chemicals in this category are chlorinated solvents.

ORM-B = Department of Transportation hazardous materials classification "Other Regulated Material-B". These are chemicals capable of causing significant damage to transport vehicle from leakage during transportation.

ORM-E = Department of Transportation hazardous materials classification "Other Regulated Material-E". This category includes materials that are to included in any other hazard class, but it is subject to appropriate transportation regulations. Materials in this class include hazardous materials and wastes.

OP = Organic Peroxide waste.

WR = Water Reactive waste.

FIGURE 8-1
RESEARCH INSTITUTE CHEMICAL WASTE
DISPOSAL - LABPACK VS. BULK

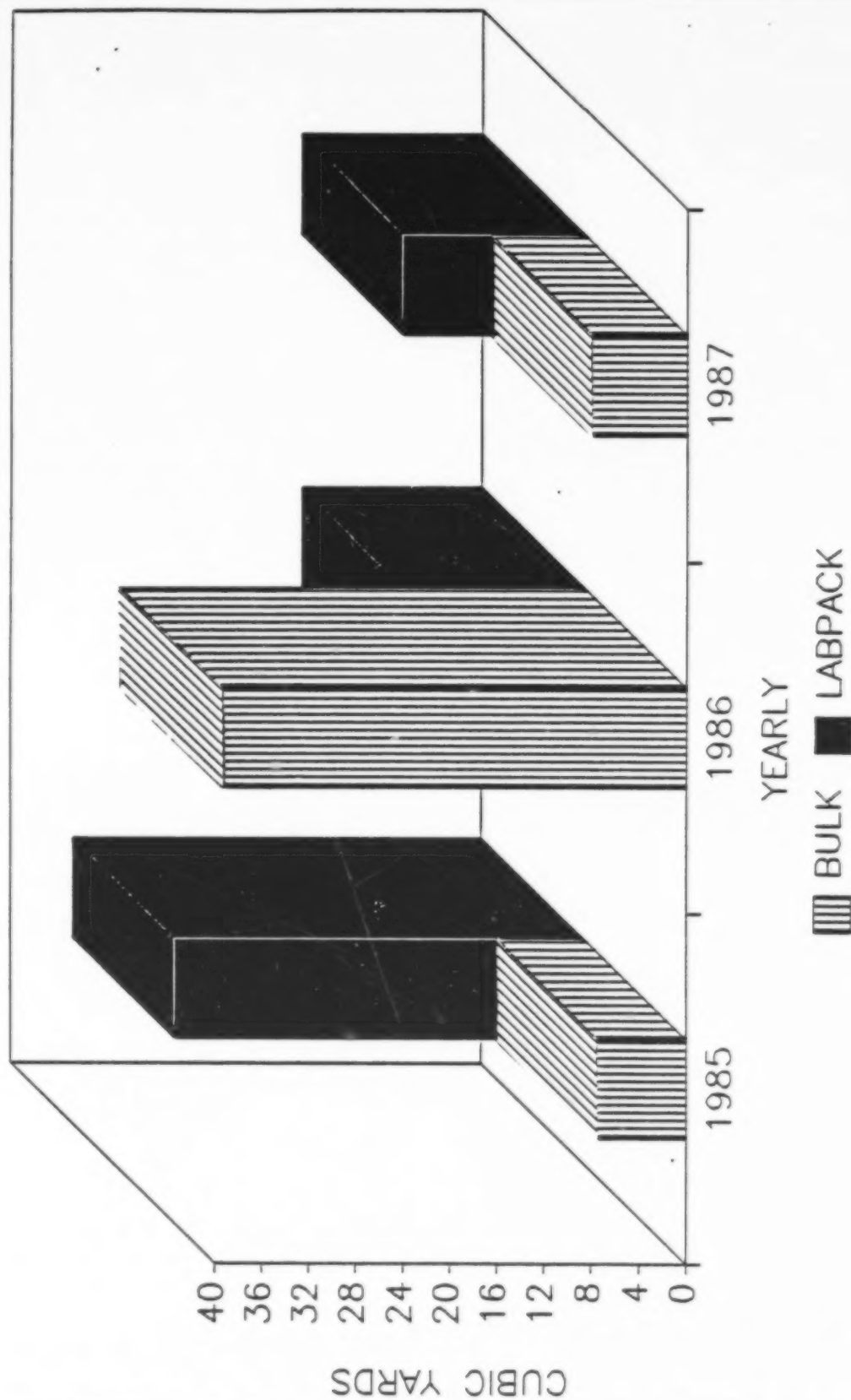


FIGURE 8-2
HAZARDOUS WASTE DISPOSAL FOR THE
RESEARCH INSTITUTE

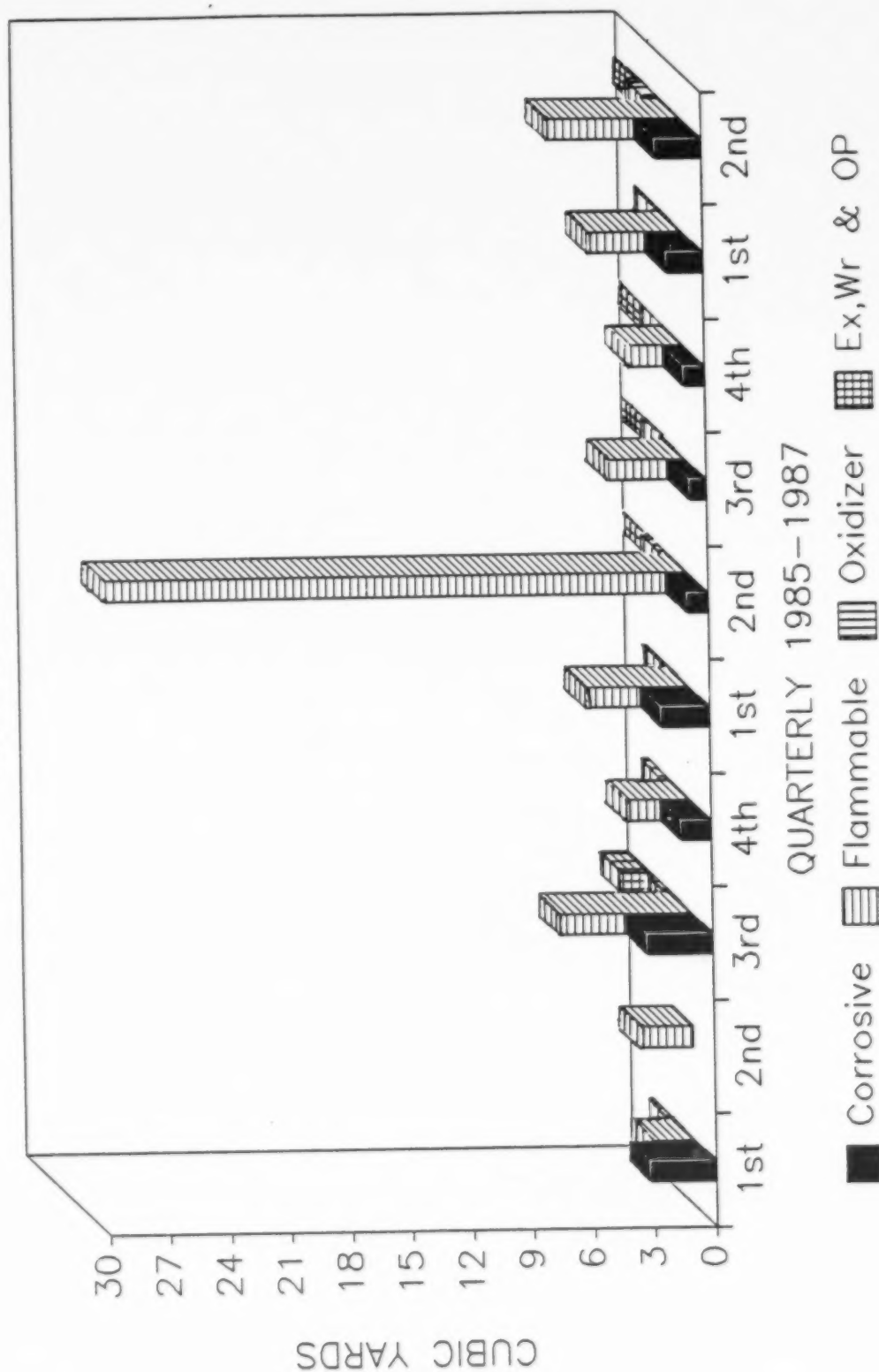
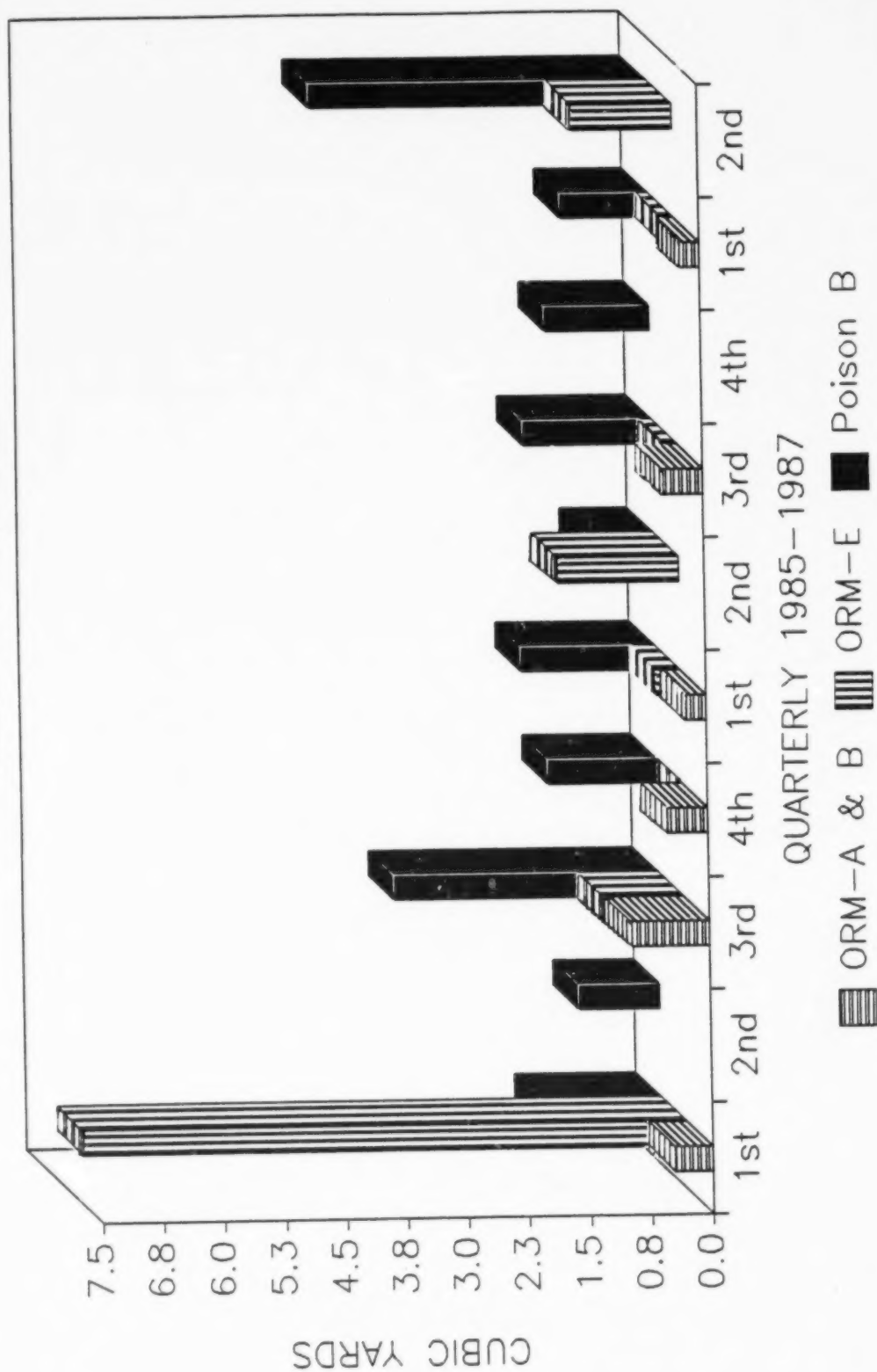


FIGURE 8-2 (CONT)
HAZARDOUS WASTE DISPOSAL FOR THE
RESEARCH INSTITUTE



8.2.2 Biology Department

The biology department uses a wide range of solvents, acids, bases, heavy metals and stains. The department is divided between neurobiology and cellular/molecular biology. Cellular/molecular biology generates the most hazardous waste. There are two chemical stockrooms, one for each subdivision. One stockroom surveyed had over 300 different chemicals in stock. A partial listing of these chemicals can be found in Appendix B. The stockrooms also store waste chemicals prior to transfer to the campus waste storage area. The highest volume chemical used is ethanol at 1500 gal/yr. Formaldehyde is used at 150 gal/year. Chlorinated solvents are used in small quantity.

The scarcity and expense in obtaining usable material to study (i.e. DNA, proteins) reduces waste generation. The increased use of chromatography and other micro-analytical techniques has also reduced waste generation.

Awareness of safety and environmental issues has grown in the last two years. Not as many chemicals are disposed of down drains and there is increased concern for handling chemicals safely.

Researchers do share chemicals. Similar research focus and the proximity of laboratories to one another promote sharing.

8.2.3 Geology and Physics

Geology and physics generate small amounts of waste solvents and assorted inorganic compounds. Acids and bases are neutralized and poured down the drain. In geology analytical techniques are micro scale. A one gram sample is large for most analyses. In physics the waste streams are 15 gallons of solvent per month (mostly alcohols), metals (mainly arsenic), and assorted inorganic salts and cyanides. In both disciplines increased instrumentation has reduced chemical usage.

8.2.4 Engineering and Environmental Science

Engineering has the following subdivisions: environmental, chemical, materials, fluid, mechanical, electrical and others. Different chemicals are used in each subdivision.

Instrumentation is used in most laboratories which has reduced chemical usage.

8.2.5 Plant Operations and Maintenance

Plant operations and maintenance generate waste solvents, paint and oil. Oil-based paints are being phased out and replaced with water-based paints. The only oil-based painting to continue will be for metal objects. Two 55-gal drums of waste thinner are generated per year from oil-based painting.

The grounds department applies fertilizers and pesticides to the lawns, trees and shrubs. The department is phasing out restricted pesticides and substituting non-toxic ones. Use of irrigation injection and water-soluble gravel pesticides that are spread on the grounds and watered into soil are being investigated. This will eliminate spraying operations.

Many academic departments have specialty machine shops that generate waste solvents and oils.

8.3. Trends in Waste Management Practices

A driving force for reducing chemical usage is economics. In biology the drive to reduce overhead costs has increased sharing of chemicals between researchers, increased use of micro-analytical techniques, and reduced the quantity of reagent chemicals purchased. In other departments, limited research funding is increasing the efficient use of chemicals.

Whenever a professor retires or leaves there is a large number of chemicals left behind in their laboratory. Most of the chemicals are disposed of in lab packs. Some are retained for internal exchange and recycle.

8.4. Recommendations for Waste Reduction

There are many opportunities for waste reduction beyond the efforts currently being implemented. These additional opportunities are:

- Establish an internal waste manifesting system to create a data base on generation of hazardous waste. This information can be put onto a computer data base.

- After waste generation data is collected, determine the quantities of waste generated for the entire campus and for each department. Establish yearly waste reduction goals for the campus and for each department. Appoint one person in each department to carry out the waste reduction policy. A campus waste reduction committee should be established to set goals and monitor progress.
- To eliminate the need for chromic acid washing of glassware either increase the use of disposable plastic glassware, or clean glassware with specialty detergents.
- Increase the amount of in-lab destruction of waste chemicals. Many toxic and corrosive waste chemicals can be converted to nonhazardous chemicals via chemical treatment (see reference "Prudent Practices for Disposal of Chemicals From Laboratories", National Research Council, 1983; Chapter 6). Waste destruction should be the final procedure for experiments.
- Purchase small solvent distillers for recovery and recycle of spent solvents. Recycled solvents can be used for cleaning or other processes where ultra pure solvent is not required.
- Purchase laboratory chemicals, paints, and other maintenance chemicals in small sizes only. This will reduce generation of surplus materials requiring disposal.
- Establish a tracking system for chemicals from purchase to disposal. This will reduce duplicate purchases, and minimize the waste generated from old, partially used containers that age on laboratory shelves. A bar coding system would enhance inventory control. Each chemical would have a different code which allows efficient tracking. This system will also assist in promoting sharing of surplus chemicals.
- Hire additional staff to assist in waste collection, data management (i.e. internal manifests), and dissemination of waste reduction information.
- Encourage use of the intra-campus chemical exchange/recycle program.
- Provide routine self-audits for professors' laboratory

ries. Focus on unused reagent accumulation and recyclable wastes.

CHAPTER 9

WASTE AUDIT OF A SMALL COLLEGE

A private liberal arts college was audited as part of the study. The student population is less than 2000. Undergraduate degrees are offered in physical sciences, social sciences and humanities. A few departments such as biology offer a Masters Degree.

9.1 Waste Management Overview

No waste management program was in effect at the college. One chemistry professor had organized a waste collection program for waste chemicals. Appendix C contains a list of chemicals that were disposed of in lab packs in 1986. That was the second off-site shipment of waste chemicals. The first shipment was in 1983. The college administration is considering hiring a part-time Safety/Waste Management Officer and implementing a formal safety/waste management program.

Since there is no formal program, concerned professors take a "piecemeal" approach to waste management. There is no budget for chemical safety and waste disposal. Each time a safety or waste disposal expenditure is necessary, it must come out of a department's budget or be obtained from general college funds, which is difficult and slow.

The above description correlates with findings of a recent EPA study (17). The EPA found that large universities with extensive research programs have established waste management programs. Small colleges and secondary schools have small programs or none at all.

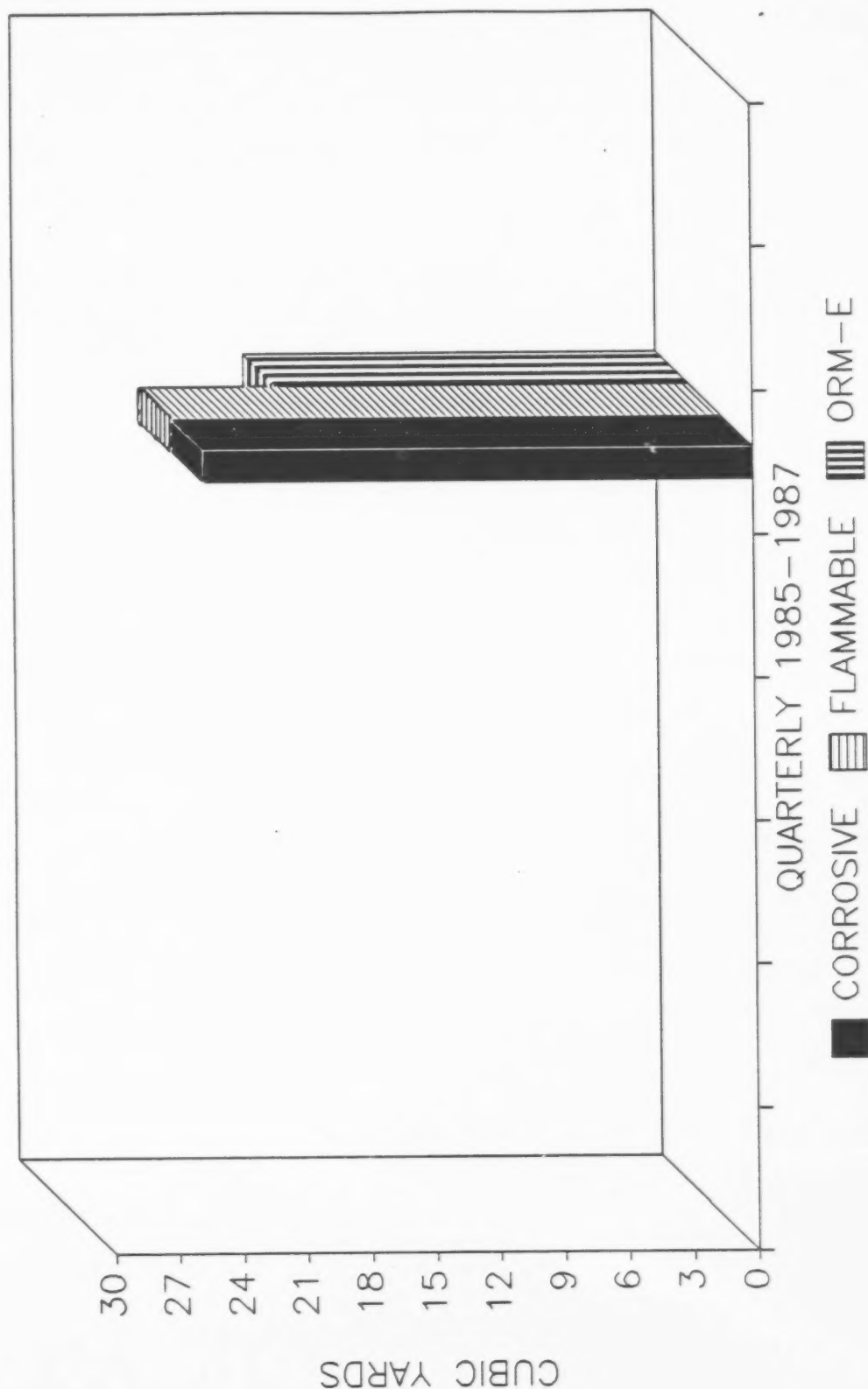
9.2 Waste Sources

Waste generation was found in chemistry, general biology, marine biology, psychology, art, maintenance, and the school newspaper. Figure 9-1 shows waste streams generated at the college.

9.2.1 Chemistry Department

The department is strictly undergraduate with an emphasis on research. Diverse organic and inorganic chemicals are used in laboratory exercises and research. Most waste (60-75%)

FIGURE 9-1
HAZARDOUS WASTE DISPOSAL FOR THE
SMALL PRIVATE COLLEGE



comes from general chemistry. The following wastes are generated in general chemistry: iodine, xylene, naptha, p-dichlorobenzene, mercury, chromium, lead and carbon tetrachloride. Research does not generate significant waste. Benzene is used in one project, but is recycled. Use of instrumentation has reduced the volume of chemicals used.

9.2.2 Biology Department

There is a small graduate program in addition to undergraduate study. Chemicals used in the department are organic solvents, heavy metals, acids, bases, stains, enzymes, and other organic compounds. Chemical waste generation includes formaldehyde, mercury salts, solvents and old chemicals. Acids and bases go down the drain. A small amount of osmium tetroxide is also generated.

Marine biology generates small amounts of acids, bases, alcohols, and chlorinated solvents. Formalin is generated in larger quantities. The college has not been able to dispose of old formalin. Over 250 gallons of formalin has accumulated thus far.

9.2.3 Art Department

The art department generates acids, waste paint and solvents from silk screen and printing processes. The department is switching from oil based paints to water-based paints. This will eliminate use of thinners. Ventilation is not adequate in many studios. As a result many volatile compounds are being phased out.

9.2.4 Waste Generation From Other Sources

Psychology generates waste solvent. The school newspaper uses photo processing chemicals (organic acids, bases, chromic acid cleaning solution) and waste chemicals are generated. The maintenance department generates waste oil. The paint shop uses water-based paints only. The grounds crew applies pesticides to lawns and trees. To avoid generation of waste pesticide they completely use up each application load.

9.3 Trends in Waste Management Practices

As a result of increased environmental regulations many changes have occurred. The chemistry department has: phased out carcinogenic compounds such as benzene and chloroform,

purchased flammable storage cabinets, and installed a better ventilation system. There has been a reduction in the volume of chemicals used in laboratory course work. Typically one quarter the quantity of chemicals called for in laboratory manuals are used in teaching laboratory experiments.

In biology changes are less noticeable than in chemistry. Many professors do not support waste collection programs and new safety protocol. Chemical disposal down drains still occurs.

A significant increase in the amount of analytical instrumentation used in research has decreased the amount of chemicals used. Teaching laboratories still use wet chemistry methods.

9.4. Recommendations for Waste Reduction

The following recommendations can improve waste management and promote waste reduction:

- Establish a new administrative position entitled "Hazardous Material/Waste Management Officer". Duties would include chemical safety, waste collection, disposal, inventory control, establishing an intracampus chemical exchange program, respond to spills, and development of a waste reduction program. This position may require only 20 hours per week, so other functions could be performed (i.e. teach, security functions, etc.).
- Establish a separate budget for chemical safety and waste management and charge it back to the departments that generate hazardous waste. This will provide an economic incentive to reduce waste.
- Eliminate use of toxic compounds in laboratory experiments by substituting a less toxic/hazardous compound, and/or using a different experiment entirely.
- Establish a central location for waste chemical storage. This area should be well ventilated, secure, contain a fire extinguisher, eye wash, shower, allow for segregated storage of incompatible chemicals, and be surrounded by berms to contain spills. The area can be used to store surplus reagent chemicals which are to be recycled within the college.

- Substitute less hazardous chemicals for cleaning the photo processor machines in the school newspaper office. Present use of chromic acid cleaning solutions creates unnecessary safety and disposal problems.
- Have printing done off-site. If the school newspaper obtains educational value from the printing activity, printing instruction can be contracted to a nearby technical school.
- Coordinate with other small colleges to have laboratory instruction done at one location. This would allow consolidation of laboratory waste generation.
- Eliminate drain disposal of all toxic and hazardous wastes.
- Increase the amount of in-lab destruction of waste chemicals. Many waste chemicals can be converted to nonhazardous chemicals via chemical treatment (see reference "Prudent Practices for Disposal of Chemicals From Laboratories", National Research Council, 1983). Waste destruction should be the final procedure for experiments.
- Increase the use of instrumentation in undergraduate laboratory course work.
- For pesticide application, investigate the use of irrigation injection of pesticides to replace spraying operations. Use of irrigation injection will reduce the amount of pesticide and rinse waters generated. Special plumbing modifications to the sprinkler systems will allow direct input of pesticides to the sprinkler system. Another alternative is applying pesticides in the dry powder form and watering them into the soil.

Glossary

California Occupational Safety and Health Administration - (Cal-OSHA) The California Occupational Safety and Health Administration, Division of the Department of Industrial Relations. This agency enforces worker safety guidelines. At present it has authority over public institutions/facilities only.

Chlorinated solvent - a solvent containing atoms of chlorine. These solvents are usually nonflammable and give off toxic vapors. Examples are carbon tetrachloride, trichloroethane, perchloroethylene, trichlorotrifluoroethane.

DHS - State of California Department of Health Services, the principal state agency in charge of regulating hazardous waste management.

EPA - U.S. Environmental Protection Agency, the federal agency in charge of hazardous waste management and other environmental protection functions.

EPA Identification Number - a twelve digit number issued by EPA or DHS to generators, transporters, and treatment, storage and disposal facility operators, based on certain requirements. These numbers must appear on all paperwork associated with hazardous waste generation, storage, transportation, treatment and/or disposal.

Generator - any person who produces hazardous waste as a result of a manufacturing process or any other process. A person who generates a waste must determine if the waste is hazardous (see definition of "hazardous waste" below).

Hazardous Waste - a waste that is either listed by name or has characteristics that make it hazardous under EPA or DHS regulations. See Articles 9 and 11, Chapter 30, Division 4 of Title 22 (California Code of Regulations) for specific chemicals that are classified as hazardous in California.

Hazardous Waste Management - procedures established for handling hazardous wastes. This includes procedures for collection, storage, labeling, recordkeeping, disposal and other associated tasks in-

volving management of hazardous wastes.

Hazardous Waste Manifest - a multipart document used for tracking hazardous waste shipments. National forms called "Uniform Hazardous Waste Manifests" are used for each shipment of hazardous waste. The manifests used in California require more information than the national version. Copies of each form are forwarded (by the generator, the facility operator and in some cases by the transporter) to the California Department of Health Services (DHS) so that the DHS can track each shipment from the generator to the receiving facility.

Lab-Pack - an approved device for shipment and disposal of laboratory waste. Waste laboratory chemicals in quantities of one gallon or less are segregated into compatibility groups. The groups are placed in separate drums and packaged with absorbent vermiculite or other similar chemical absorbent material. The drums are then shipped to a storage or recycling facility or to a landfill for disposal.

OSHA - U.S. Occupational Safety and Health Administration. This federal agency establishes and enforces worker safety standards.

RCRA - Resource Conservation and Recovery Act - a body of federal statutes that controls aspects of hazardous waste generation, transportation, treatment, storage and disposal.

Right-to-Know - OSHA regulation requiring employers to: (1) inform employees of toxic chemicals in the workplace, (2) train workers in safe handling of chemicals, (3) label all toxic chemicals with warnings, (4) appoint a person who will implement the program and who can respond to questions, and (5) maintain a file of material safety data sheets for each toxic chemical used. California has its own Right-to-Know law called the Hazard Communication Law. It is very similar to the federal legislation.

Waste Reduction/Minimization - the act of reducing the amount of hazardous waste generated, through source reduction (chemical substitution, process change, elimination), recycling, recovery and/or treatment.

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RALPH STONE AND COMPANY, INC.

APPENDIX A

WASTE GENERATION DATA FROM AUDIT OF A LARGE UNIVESTITY

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WASTE GENERATED FROM SOPHOMORE ORGANIC CHEMISTRY

Experiment 1: Extraction, Crystallization and Distillation

Aqueous waste: Ethanol and water, neutralized sodium salts
Organic waste: Dichloromethane with a small amount (<1g/l) of Biphenyl
Solid waste: Biphenyl in bag
Benzoic acid in bag

Experiment 2: Diels Alder

Organic waste: Ethyl acetate, Hexanes, Dicyclopentadiene
Solid waste: cis-Norbornene - 5,6-endo-dicarboxylic anhydride
cis-Norbornene - 5,6-endo-dicarboxylic acid

Experiment 5: Grignard Reaction

Organic waste: Ethyl ether with a trace of benzoic acid
Aqueous waste: Magnesium salts, neutralized sodium salts
Solid waste: Benzoic acid

Experiment 6: Benzoin Condensation

Aqueous waste: Thiamine, ethanol, sodium hydroxide, trace benzaldehyde and benzoin
Organic waste: Dichloromethane with a trace of thiamine, benzoin and benzaldehyde
Solid waste: Benzoin in bag

Experiment 8: Semicarbazide

Aqueous waste: Furfural semicarbazone, cyclohexanone semicarbazone, and methanol
Solid waste: Furfural semicarbazone and cyclohexanone semicarbazone in bag

WASTE GENERATED FROM UNDERGRADUATE BIOCHEMISTRY EXPERIMENTS

Experiment 1: Nitrophenols

Aqueous waste: o-nitrophenol, p-nitrophenol, m-nitrophenol and
2,5-dinitrophenol dissolved in ethanol and water

Experiment 2: Carbohydrate

Aqueous waste: Sodium periodate dissolved in water

Experiment 3: Invertase

Aqueous waste: Oxidation products of 3,5-dinitrosalicylate

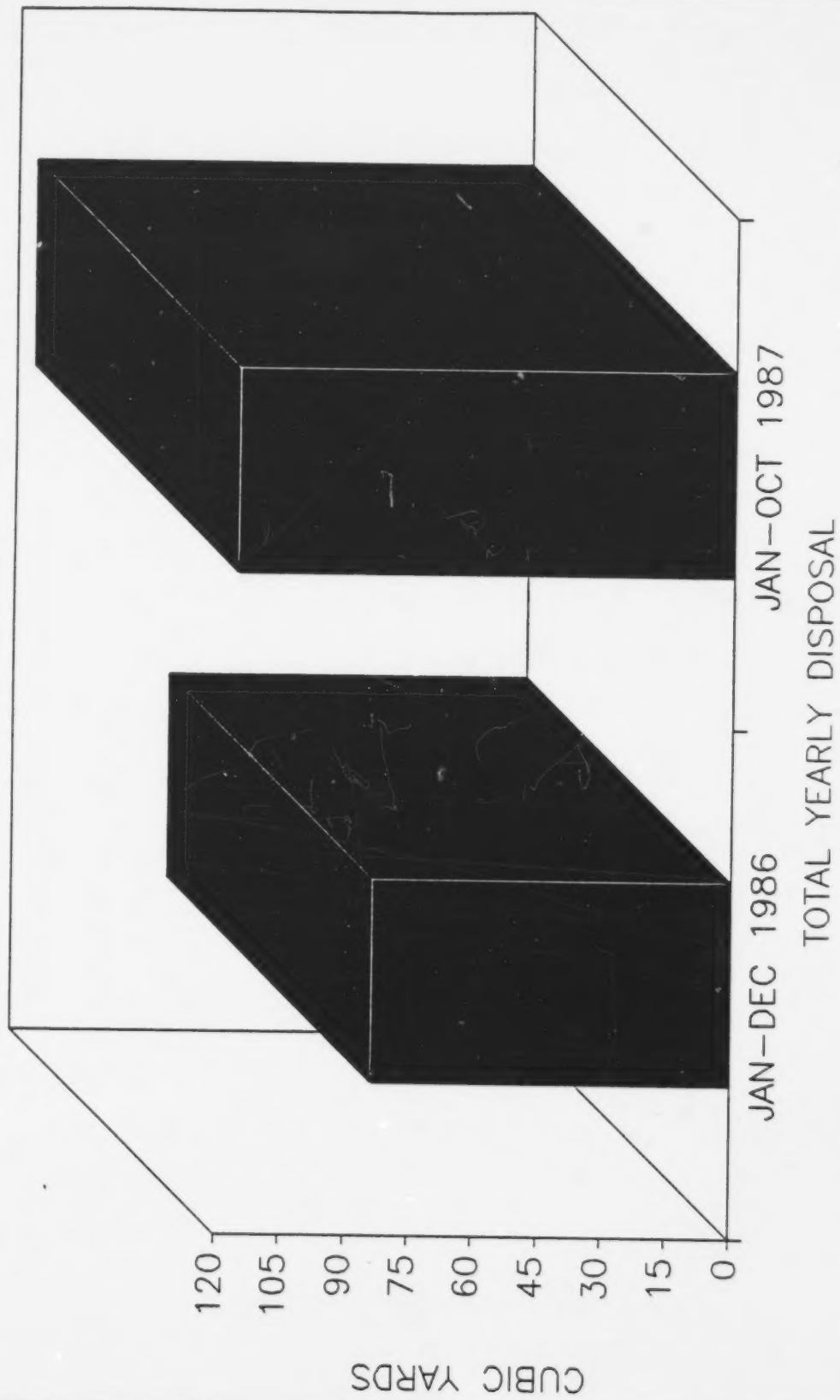
Experiment 4: Lactate dehydrogenase

None

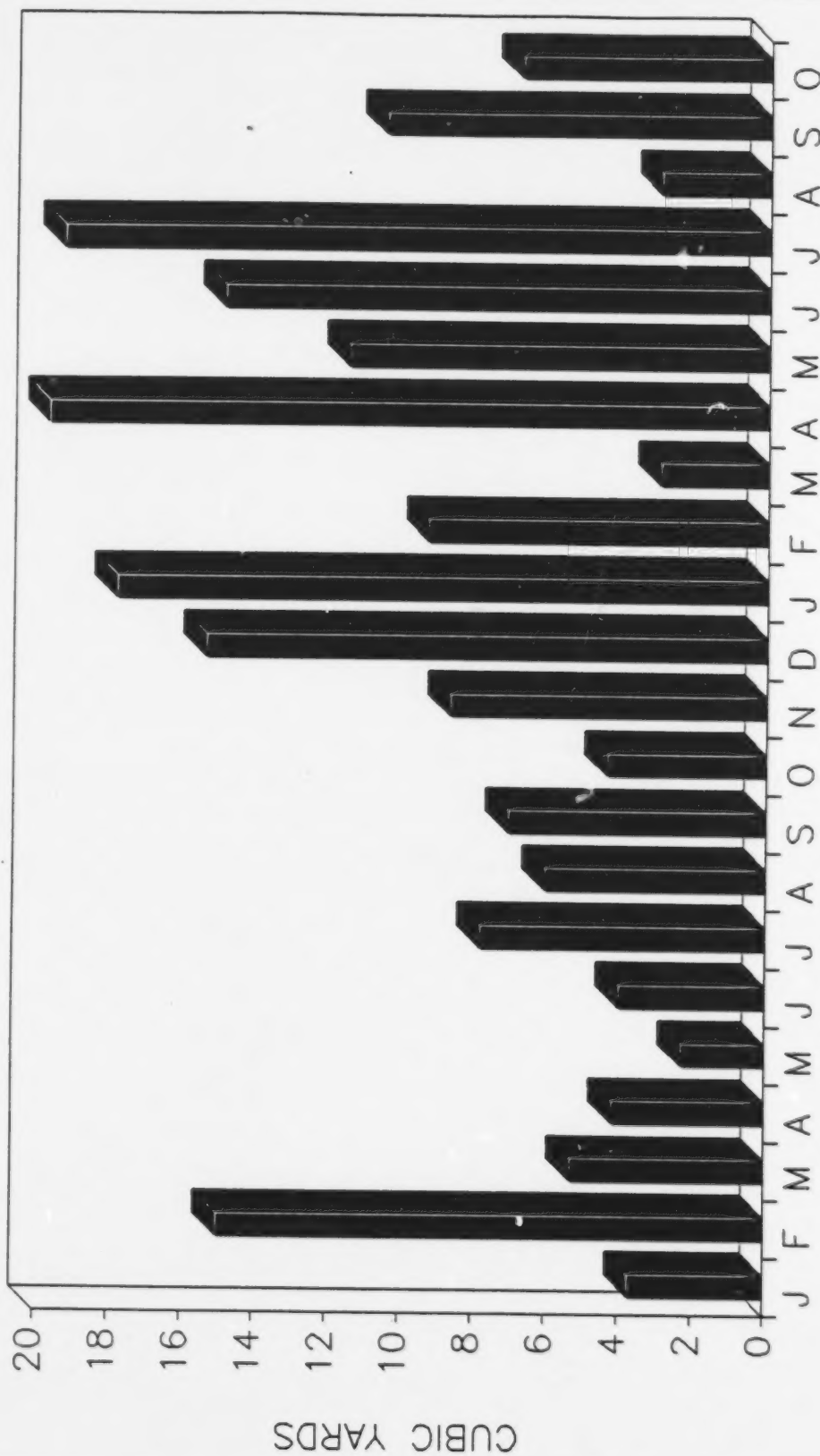
Experiment 5: B-Galactosidase

Aqueous waste: O-nitrophenol and Folin Reagent (phenol and sodium tungstate)
dissolved in water

HAZARDOUS WASTE PER YEAR
DISPOSED OF BY LARGE UNIVERSITY



WASTE PER MONTH DISPOSED OF BY LARGE UNIVERSITY



TOTAL MONTHLY DISPOSAL JAN. 86 - OCT 87

Abbreviations Found On Bar Diagrams and Graphs

Ex = Explosives

ORM-A = Department of Transportation hazardous materials classification "Other Regulated Material-A". This category includes materials which have "an anesthetic, irritating, noxious, toxic or other similar property and which can cause extreme annoyance or discomfort to passengers and crew in the event of leakage during transportation". Typical chemicals in this category are chlorinated solvents.

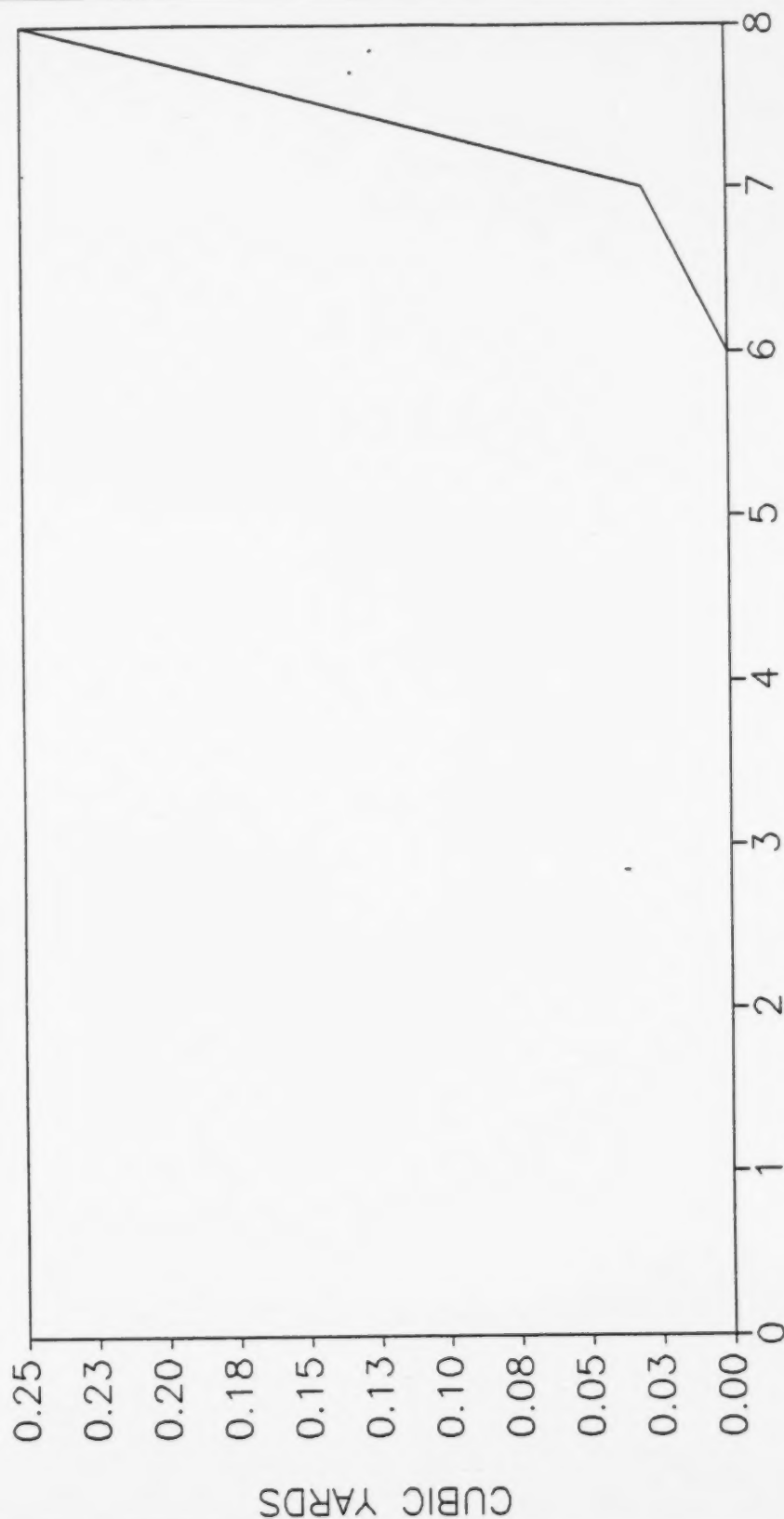
ORM-B = Department of Transportation hazardous materials classification "Other Regulated Material-B". These are chemicals capable of causing significant damage to transport vehicle from leakage during transportation.

ORM-E = Department of Transportation hazardous materials classification "Other Regulated Material-E". This category includes materials that are to included in any other hazard class, but it is subject to appropriate transportation regulations. Materials in this class include hazardous materials and wastes.

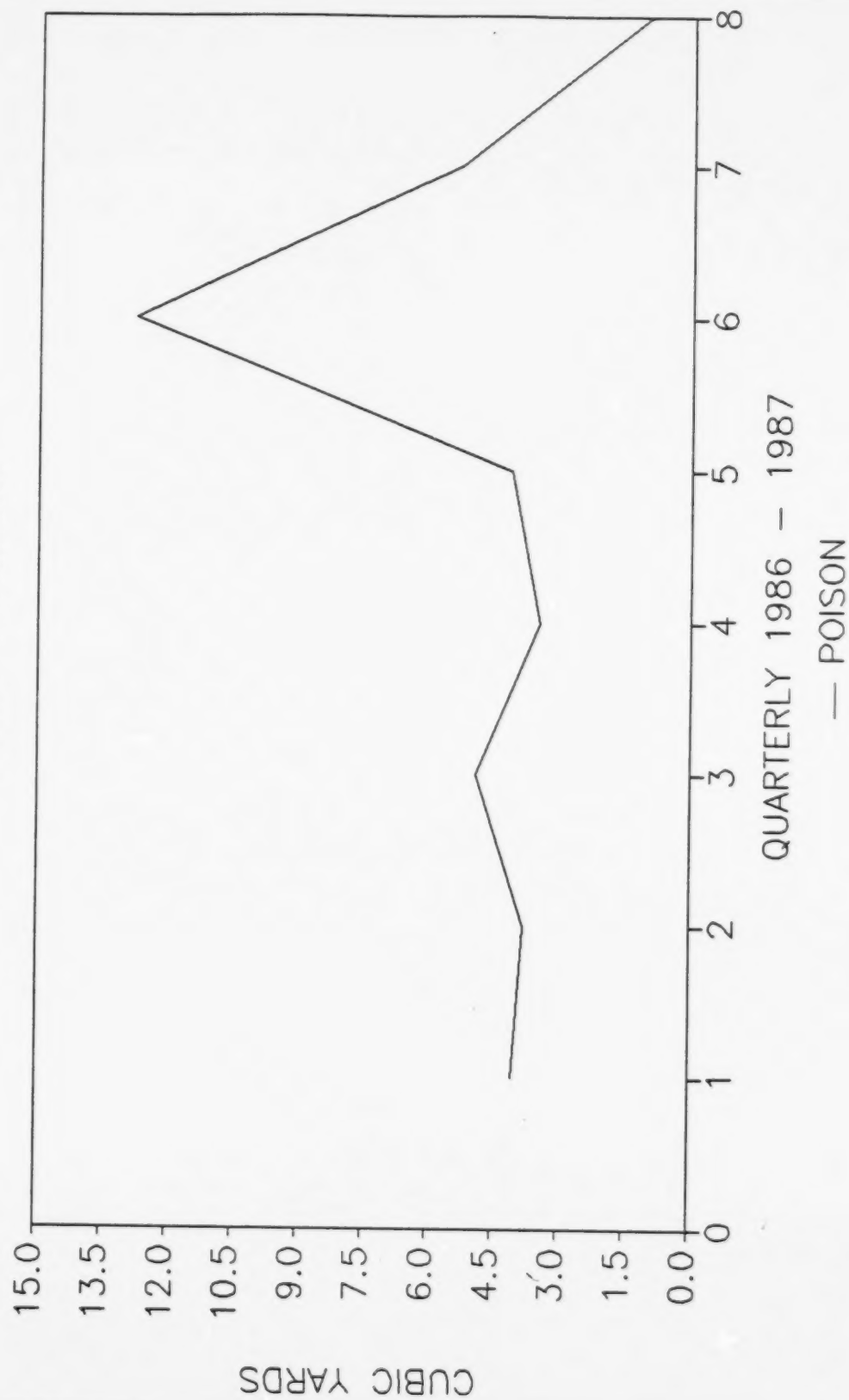
OP = Organic Peroxide waste.

WR = Water Reactive waste.

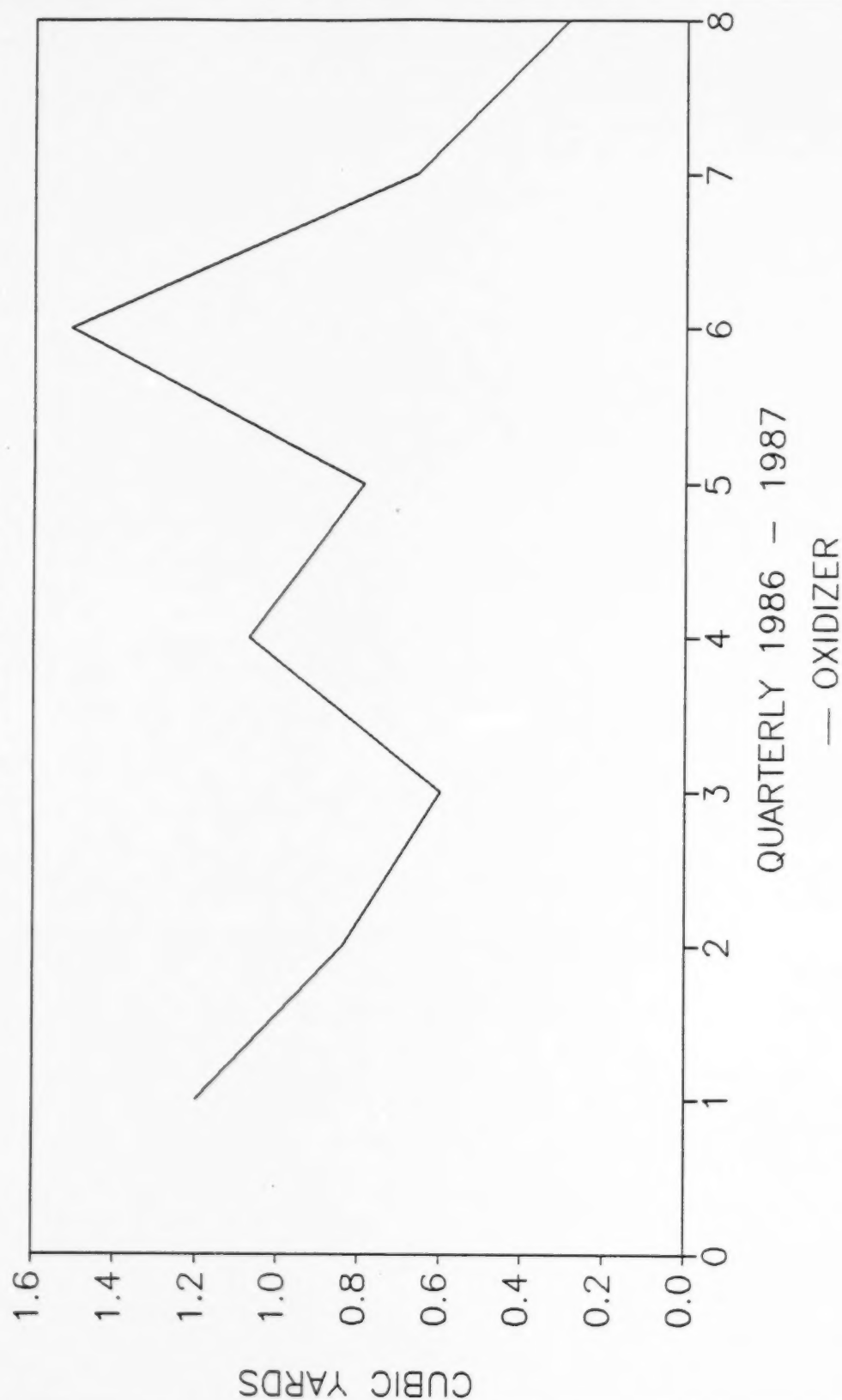
HAZARDOUS WASTE STREAM FOR THE
LARGE UNIVERSITY



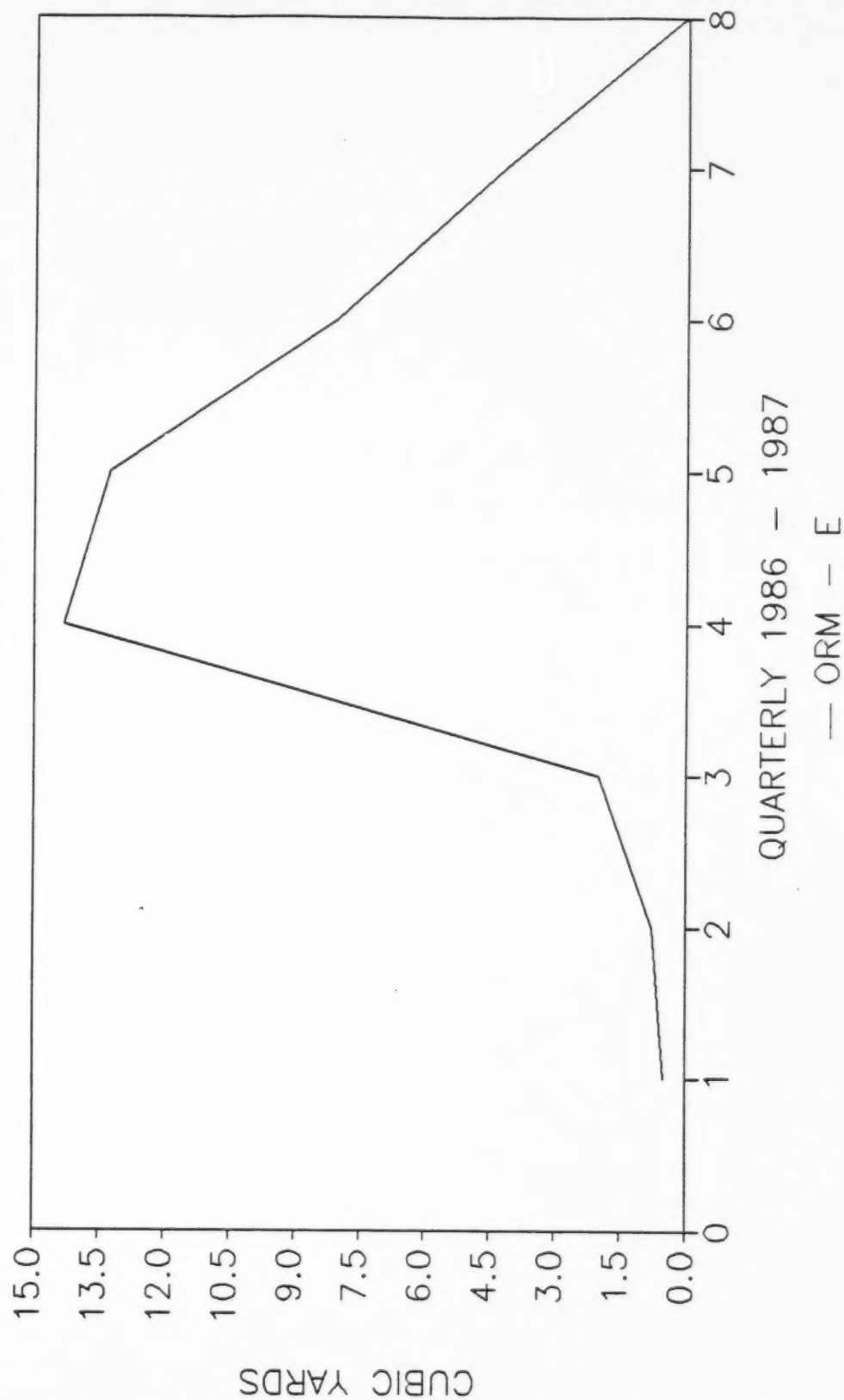
HAZARDOUS WASTE STREAM FOR THE
LARGE UNIVERSITY



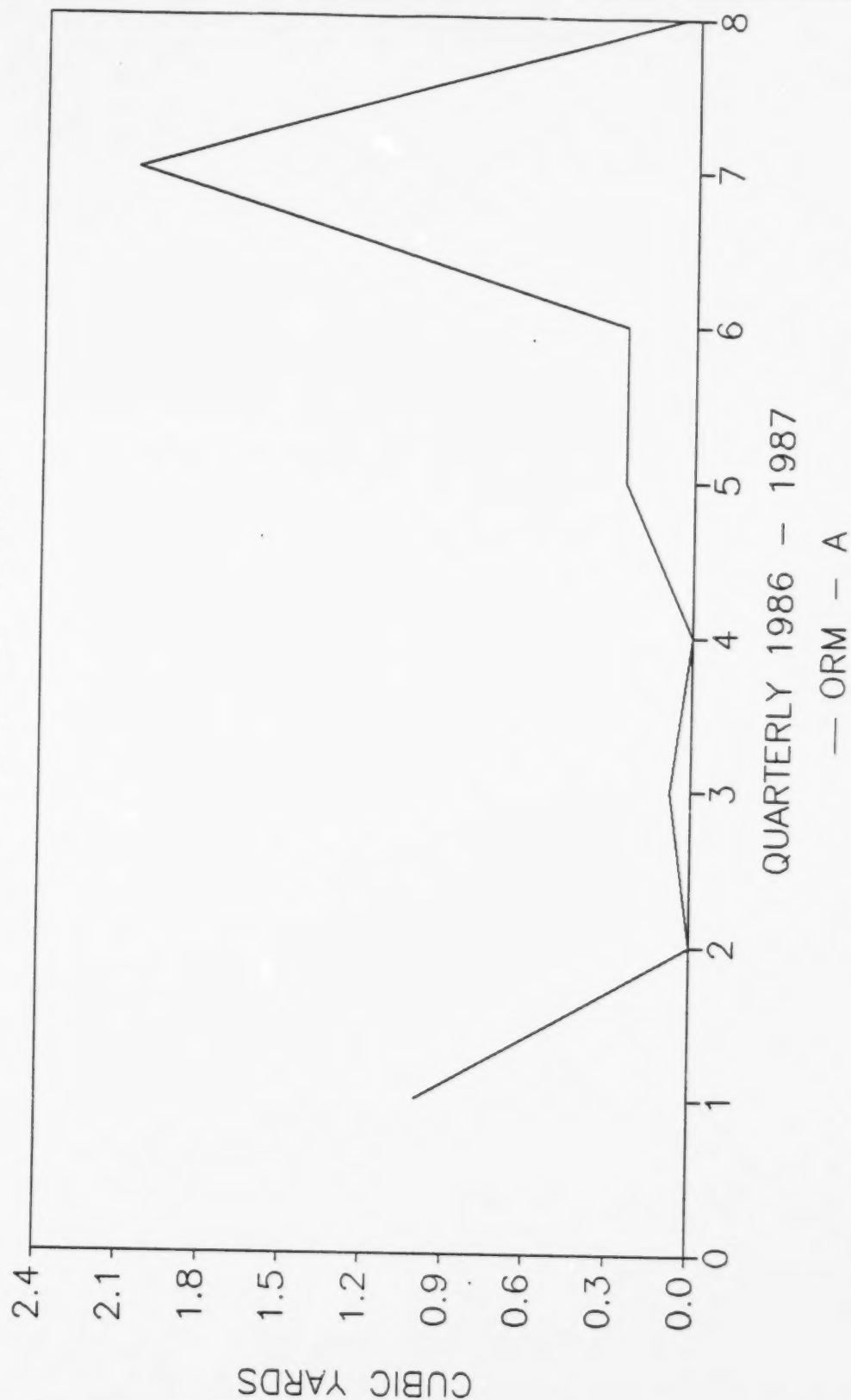
HAZARDOUS WASTE STREAM FOR THE
LARGE UNIVERSITY



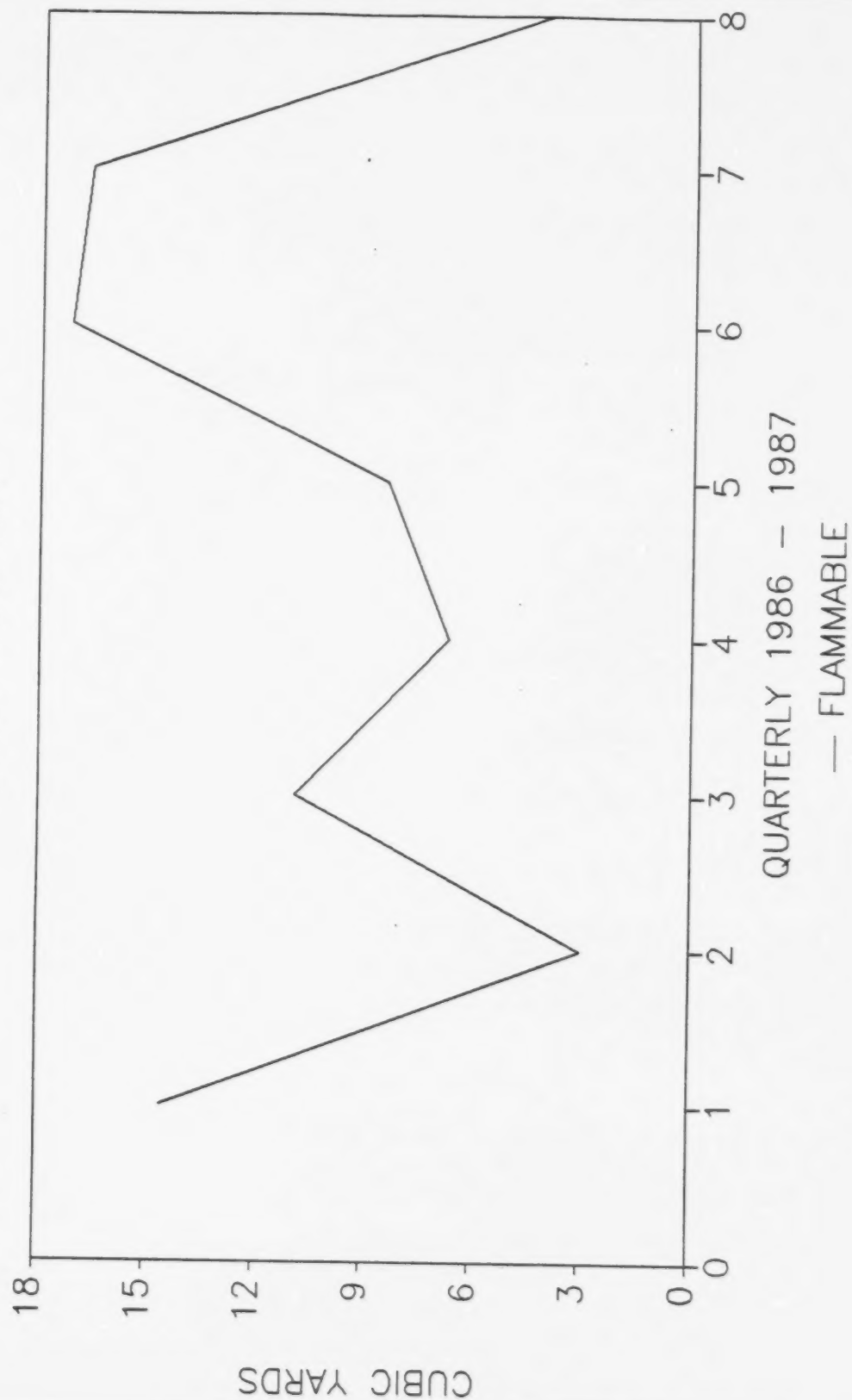
HAZARDOUS WASTE STREAM FOR THE
LARGE UNIVERSITY



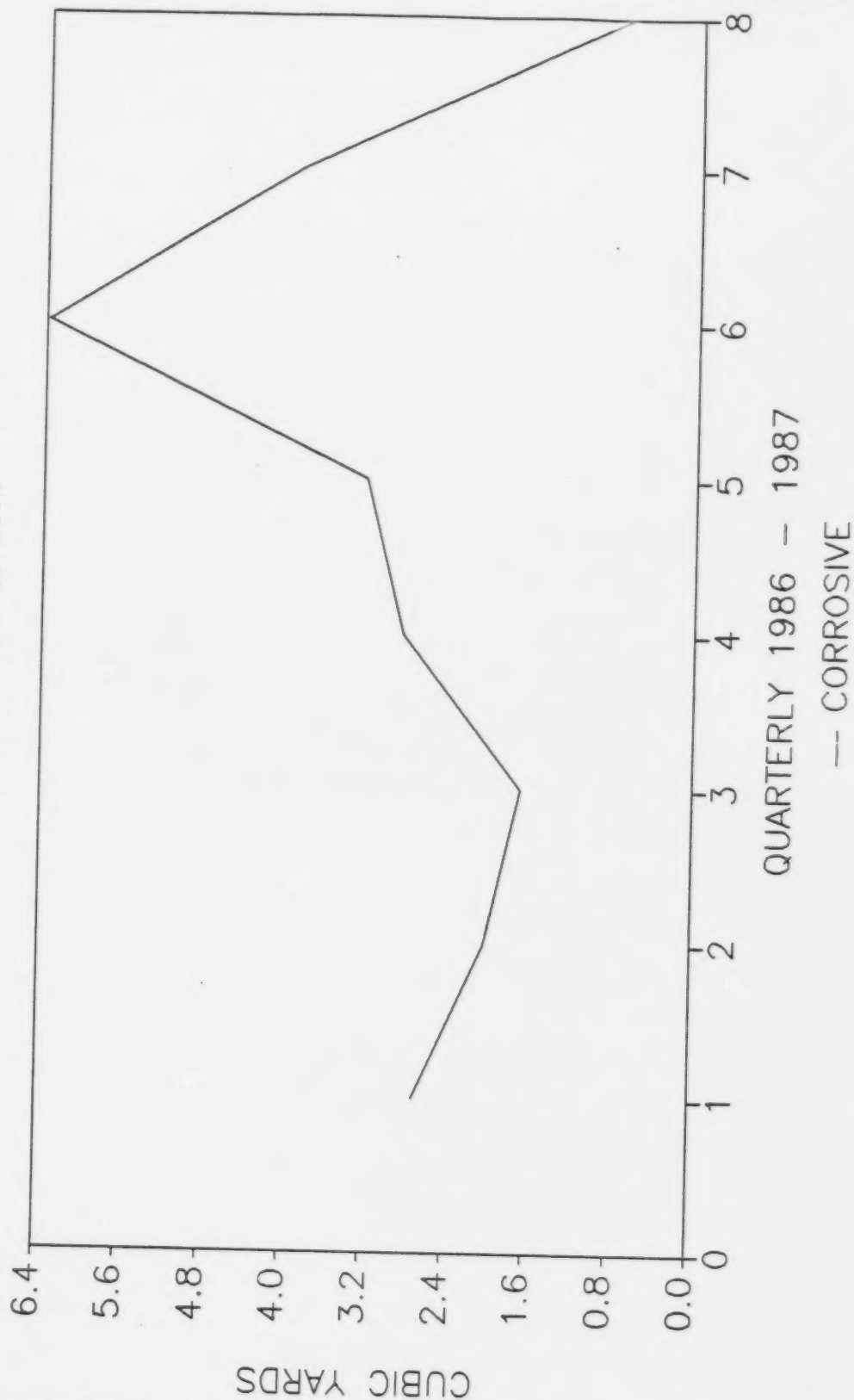
HAZARDOUS WASTE STREAM FOR THE LARGE UNIVERSITY



HAZAROUS WASTE STREAM FOR THE
LARGE UNIVERSITY



HAZARDOUS WASTE STREAM FOR THE LARGE UNIVERSITY



RALPH STONE AND COMPANY, INC.
LARGE UNIVERSITY
WASTE CHEMICAL
MANIFEST DATA

Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
1	01/09/86	211	Chlorinated Solvent	ORM-E	Liquid	Bulk	No	1.00
	01/15/86	551		Poison B	Solid	Lab pack	Yes	0.50
	01/15/86	551		ORM-E	Solid	Lab pack	Yes	0.50
	01/15/86	551	Magnesium metal	Flammable	Solid	Lab pack	Yes	0.25
	01/15/86	551		Oxidizer	Solid	Lab pack	Yes	0.15
	01/15/86	551		Corrosive	Solid	Lab pack	Yes	0.15
	01/15/86	551		Flammable	Liquid	Lab pack	Yes	0.75
	01/15/86	551	Alkaline	Poison B	Liquid	Lab pack	Yes	0.25
	01/15/86	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.50
	01/15/86	551		Poison B	Liquid	Lab pack	Yes	0.50
	01/15/86	551	Phosphoric anhydride	Corrosive	Liquid	Lab pack	Yes	0.15
	02/03/86	113	Acid	Corrosive	Unknown	Lab pack	Yes	0.40
	02/03/86	343		Flammable	Liquid	Lab pack	Yes	0.40
	02/03/86	551		Poison B	Liquid	Lab pack	Yes	0.25
	02/03/86	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.15
	02/03/86	551		Corrosive	Solid	Lab pack	Yes	0.15
	02/03/86	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.25
	02/03/86	551		Poison B	Solid	Lab pack	Yes	0.90
	02/03/86	551		Oxidizer	Unknown	Lab pack	Yes	0.25
	02/03/86	551	Sodium hydrogen sulfate	ORM-B	Unknown	Lab pack	Yes	0.25
	02/24/86	291	Paint	Flammable	Solid	Lab pack	Yes	12.00
	03/05/86	551		Flammable	Liquid	Lab pack	Yes	0.75
	03/05/86	551	Acid	Corrosive	Unknown	Lab pack	Yes	0.40
	03/05/86	551		Flammable	Solid	Lab pack	Yes	0.25
	03/05/86	551	Formalin	ORM-A	Liquid	Lab pack	Yes	0.75
	03/05/86	551		Oxidizer	Unknown	Lab pack	Yes	0.25
	03/05/86	551	Nitric acid	Oxidizer	Unknown	Lab pack	Yes	0.15
	03/05/86	551	Sulfuric acid	Oxidizer	Unknown	Lab pack	Yes	0.40
	03/05/86	551		Corrosive	Liquid	Lab pack	Yes	0.15
	03/05/86	551	Hydrazine anhydrous	Flammable	Liquid	Lab pack	Yes	0.15
	03/05/86	551		Poison B	Unknown	Lab pack	Yes	1.25
	03/05/86	551	Alkaline	Corrosive	Unknown	Lab pack	Yes	0.25
	03/05/86	551		Corrosive	Unknown	Lab pack	Yes	0.30
	03/05/86	551		Poison B	Liquid	Lab pack	Yes	0.25

QUARTER TOTAL								25.00

2	04/04/86	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.25
	04/04/86	551		Corrosive	Liquid	Lab pack	No	0.14
	04/04/86	551		Corrosive	Solid	Lab pack	No	0.40
	04/04/86	551		Flammable	Liquid	Lab pack	No	1.40
	04/04/86	551		Flammable	Solid	Lab pack	No	0.07
	04/04/86	551		Poison B	Liquid	Lab pack	No	0.25
	04/04/86	551		Poison B	Solid	Lab pack	No	1.25
	04/04/86	551	Nitric acid fuming	Oxidizer	Liquid	Lab pack	No	0.02
	04/04/86	551		Oxidizer	Solid	Lab pack	No	0.25
	04/04/86	551	Nitric acid	Oxidizer	Liquid	Lab pack	No	0.07
	04/04/86	551	Acid	Corrosive	Solid	Lab pack	No	0.07

RALPH STONE AND COMPANY, INC.
LARGE UNIVERSITY
WASTE CHEMICAL
MANIFEST DATA

Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
2	05/23/86	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.25
	05/23/86	551	Nitric acid	Oxidizer	Liquid	Lab pack	Yes	0.08
	05/23/86	551		Oxidizer	Unknown	Lab pack	Yes	0.08
	05/23/86	551		Poison B	Liquid	Lab pack	Yes	0.25
	05/23/86	551		Flammable	Liquid	Lab pack	Yes	0.50
	05/23/86	551		Corrosive	Solid	Lab pack	Yes	0.28
	05/23/86	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.08
	05/23/86	551		Poison B	Solid	Lab pack	Yes	0.75
	06/06/86	551		ORM-E	Liquid	Lab pack	Yes	0.25
	06/06/86	551		Poison B	Liquid	Lab pack	Yes	0.25
	06/06/86	551		Poison B	Solid	Lab pack	Yes	0.65
	06/06/86	551		ORM-E	Solid	Lab pack	Yes	0.03
	06/06/86	551		Flammable	Solid	Lab pack	Yes	0.03
	06/06/86	551		Oxidizer	Unknown	Lab pack	Yes	0.15
	06/06/86	551	Acid	Corrosive	Solid	Lab pack	Yes	0.15
	06/06/86	551		Flammable	Liquid	Lab pack	Yes	0.25
	06/06/86	551	Nitric acid	Oxidizer	Liquid	Lab pack	Yes	0.08
	06/06/86	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.25
	06/16/86	113	Nitric acid	Oxidizer	Liquid	Lab pack	Yes	0.08
	06/16/86	551	Cyanide	Poison B	Unknown	Lab pack	Yes	0.15
	06/16/86	551		Flammable	Liquid	Lab pack	Yes	0.75
	06/16/86	551		Corrosive	Liquid	Lab pack	Yes	0.15
	06/16/86	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.25
	06/16/86	551		Oxidizer	Unknown	Lab pack	Yes	0.03
	06/16/86	551		ORM-E	Liquid	Lab pack	Yes	0.50
								QUARTER TOTAL 10.44
3	07/03/86	343	Formaldehyde	ORM-A	Liquid	Lab pack	Yes	0.75
	07/03/86	461	Paint	Flammable	Unknown	Lab pack	Yes	3.25
	07/03/86	461		Flammable	Liquid	Lab pack	Yes	1.25
	07/16/86	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.15
	07/16/86	551		Flammable	Solid	Lab pack	Yes	0.03
	07/16/86	551		Corrosive	Solid	Lab pack	Yes	0.15
	07/16/86	551		Poison B	Solid	Lab pack	Yes	0.25
	07/16/86	551		Poison B	Liquid	Lab pack	Yes	0.25
	07/16/86	551		Oxidizer	Unknown	Lab pack	Yes	0.08
	07/16/86	551	Phosphoric anhydride	Corrosive	Solid	Lab pack	Yes	0.03
	07/16/86	551	Nitric acid	Oxidizer	Solid	Lab pack	Yes	0.03
	07/16/86	551		ORM-E	Liquid	Lab pack	Yes	0.50
	07/16/86	551		Flammable	Liquid	Lab pack	Yes	1.08
	08/18/86	551		Poison B	Unknown	Lab pack	Yes	0.50
	08/18/86	551		Corrosive	Solid	Lab pack	Yes	0.08
	08/18/86	551		ORM-E	Solid	Lab pack	Yes	0.75
	08/18/86	551		Flammable	Solid	Lab pack	Yes	0.08
	08/18/86	551	Nitric acid	Oxidizer	Liquid	Lab pack	Yes	0.08
	08/18/86	551		Corrosive	Solid	Lab pack	Yes	0.08
	08/18/86	551		Flammable	Liquid	Lab pack	Yes	1.25

RALPH STONE AND COMPANY, INC.
LARGE UNIVERSITY
WASTE CHEMICAL
MANIFEST DATA

Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
3	08/18/86	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.25
	08/18/86	551		Poison B	Solid	Lab pack	Yes	0.50
	08/18/86	551		Flammable	Liquid	Lab pack	Yes	0.15
	08/18/86	551		Flammable	Solid	Lab pack	Yes	0.08
	08/18/86	551		Flammable	Liquid	Lab pack	Yes	0.25
	08/18/86	551		Poison B	Liquid	Lab pack	Yes	0.25
	08/18/86	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.50
	08/18/86	551		Poison B	Solid	Lab pack	Yes	1.00
	08/18/86	551		Oxidizer	Liquid	Lab pack	Yes	0.08
	08/18/86	551		Flammable	Liquid	Lab pack	Yes	0.15
	09/22/86	214		Flammable	Liquid	Lab pack	Yes	0.75
	09/29/86	212		Flammable	Liquid	Lab pack	Yes	0.25
	09/29/86	551		Poison B	Solid	Lab pack	Yes	1.08
	09/29/86	551		Oxidizer	Unknown	Lab pack	Yes	0.25
	09/29/86	551		Poison B	Liquid	Lab pack	Yes	1.08
	09/29/86	551	Nitric acid	Oxidizer	Unknown	Lab pack	Yes	0.08
	09/29/86	551		ORM-E	Solid	Lab pack	Yes	0.75
	09/29/86	551		Corrosive	Solid	Lab pack	Yes	0.41
	09/29/86	551		Flammable	Liquid	Lab pack	Yes	2.25
	09/29/86	551	Magnesium	Flammable	Solid	Lab pack	Yes	0.03
	09/29/86	551	Phosphoric anhydride	Corrosive	Unknown	Lab pack	Yes	0.03
	09/29/86	551		Flammable	Solid	Lab pack	Yes	0.08
								QUARTER TOTAL 20.87
4	10/24/86	551		Poison B	Liquid	Lab pack	Yes	0.65
	10/24/86	551		Oxidizer	Liquid	Lab pack	Yes	0.25
	10/24/86	551		Poison B	Solid	Lab pack	Yes	0.50
	10/24/86	551		Corrosive	Liquid	Lab pack	Yes	0.40
	10/24/86	551		ORM-E	Solid	Lab pack	Yes	0.75
	10/24/86	551	Nitric acid	Oxidizer	Unknown	Lab pack	Yes	0.08
	10/24/86	551	Phosphoric anhydride	Corrosive	Unknown	Lab pack	Yes	0.03
	10/24/86	551	Cyanide	Poison B	Unknown	Lab pack	Yes	0.15
	10/24/86	551		Flammable	Liquid	Lab pack	Yes	1.50
	10/24/86	551		Flammable	Solid	Lab pack	Yes	0.03
	11/19/86	551		Poison B	Liquid	Lab pack	Yes	0.75
	11/19/86	551	Perchloric acid	Oxidizer	Unknown	Lab pack	Yes	0.25
	11/19/86	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.25
	11/19/86	551		Flammable	Liquid	Lab pack	Yes	0.25
	11/19/86	551		Flammable	Solid	Lab pack	Yes	0.15
	11/19/86	551		Poison B	Liquid	Lab pack	Yes	0.50
	11/19/86	551		ORM-E	Liquid	Lab pack	Yes	0.25
	11/19/86	551	Bromine	Corrosive	Unknown	Lab pack	Yes	0.08
	11/19/86	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.15
	11/19/86	551	Nitric acid	Oxidizer	Liquid	Lab pack	Yes	0.08
	11/19/86	551		Corrosive	Liquid	Lab pack	Yes	1.20
	11/19/86	551		Oxidizer	Unknown	Lab pack	Yes	0.25
	11/24/86	291	Paint	Flammable	Liquid	Lab pack	Yes	4.50

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Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
4	12/02/86	512		ORM-E	Liquid	Lab pack	Yes	13.32
	12/18/86	151	Acid	Corrosive	Liquid	Lab pack	Yes	0.50
	12/18/86	551	Nitric acid	Oxidizer	Liquid	Lab pack	Yes	0.08
	12/18/86	551		Flammable	Liquid	Lab pack	Yes	0.25
	12/18/86	551		Poison B	Liquid	Lab pack	Yes	0.75
	12/18/86	551		Corrosive	Solid	Lab pack	Yes	0.15
	12/18/86	551		Oxidizer	Liquid	Lab pack	Yes	0.08
	12/18/86	551		Corrosive	Solid	Lab pack	Yes	0.25

QUARTER TOTAL								28.38

1	01/13/87	731	Polychlorinated biphenyls	ORM-E	Solid	Lab pack	No	2.00
	01/15/87	731	Polychlorinated biphenyls	ORM-E	Unknown	Lab pack	No	1.75
	01/17/87	731	Polychlorinated biphenyls	ORM-E	Solid	Lab pack	No	0.50
	01/17/87	731	Polychlorinated biphenyls	ORM-E	Unknown	Lab pack	No	0.56
	01/21/87	213	Xylene	Flammable	Liquid	Bulk	No	0.75
	01/21/87	214		Flammable	Liquid	Bulk	No	2.50
	01/21/87	322		ORM-E	Solid	Lab pack	Yes	1.25
	01/21/87	551		Poison B	Liquid	Lab pack	Yes	0.50
	01/21/87	551		Corrosive	Liquid	Lab pack	Yes	0.33
	01/21/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.25
	01/21/87	551	Sulfuric Acid	Corrosive	Liquid	Lab pack	Yes	0.25
	01/21/87	551	Acetic Acid	Corrosive	Liquid	Lab pack	Yes	0.08
	01/21/87	551	Nitric Acid	Oxidizer	Liquid	Lab pack	Yes	0.15
	01/21/87	551		Poison B	Solid	Lab pack	Yes	0.15
	01/21/87	551	Magnesium Metal	Flammable	Solid	Lab pack	Yes	0.08
	01/21/87	551		Flammable	Liquid	Lab pack	Yes	1.75
	01/21/87	551	Phosphorus, Amorphous Red	Flammable	Liquid	Lab pack	Yes	0.08
	01/21/87	551	Nitric Acid	Oxidizer	Liquid	Lab pack	Yes	0.08
	01/23/87	551		Corrosive	Liquid	Lab pack	Yes	0.31
	01/23/87	551		Flammable	Liquid	Lab pack	Yes	0.50
	01/23/87	551		Flammable	Solid	Lab pack	Yes	0.08
	01/23/87	551	Bromine	Corrosive	Unknown	Lab pack	Yes	0.08
	01/23/87	551		Poison B	Solid	Lab pack	Yes	1.25
	01/23/87	551		Oxidizer	Unknown	Lab pack	Yes	0.25
	01/23/87	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.25
	01/23/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.25
	01/23/87	551	Cyanide	Poison B	Liquid	Bulk	Yes	0.15
	01/29/87	213	Petroleum Naptha	Flammable	Liquid	Lab pack	No	0.22
	01/29/87	214	Paint	Flammable	Liquid	Lab pack	No	0.44
	01/29/87	214		ORM-A	Unknown	Lab pack	No	0.25
	01/29/87	214		Flammable	Liquid	Lab pack	Yes	0.74
	01/29/87	551	Cyanide	Poison B	Unknown	Lab pack	Yes	0.05
	02/17/87	731	Polychlorinated biphenyls	ORM-E	Unknown	Lab pack	No	1.56
	02/17/87	731	Polychlorinated biphenyls	ORM-E	Unknown	Lab pack	No	3.90
	02/18/87	181	Magnesium	Flammable	Solid	Lab pack	Yes	0.03
	02/18/87	322		ORM-E	Unknown	Lab pack	Yes	1.50
	02/18/87	551		Poison B	Liquid	Lab pack	Yes	0.25

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Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)

1	02/18/87	551		Flammable	Solid	Lab pack	Yes	0.08
	02/18/87	551		Poison B	Solid	Lab pack	Yes	0.50
	02/18/87	551		Flammable	Liquid	Lab pack	Yes	0.50
	02/18/87	551		Corrosive	Unknown	Lab pack	Yes	0.08
	02/18/87	551		Corrosive	Liquid	Lab pack	Yes	0.25
	02/18/87	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.15
	02/18/87	551		Oxidizer	Unknown	Lab pack	Yes	0.08
	02/18/87	551	Nitric Acid	Corrosive	Liquid	Lab pack	Yes	0.08
	02/18/87	551	Acrolein	Flammable	Liquid	Lab pack	Yes	0.05
	02/18/87	551	Acetic Acid	Corrosive	Liquid	Lab pack	Yes	0.08
	02/18/87	551	Oleum	Corrosive	Unknown	Lab pack	Yes	0.05
	02/18/87	551	Sulfuric Acid	Corrosive	Liquid	Lab pack	Yes	0.15
	03/13/87	551		Corrosive	Solid	Lab pack	Yes	0.08
	03/13/87	551	Magnesium	Flammable	Solid	Lab pack	Yes	0.03
	03/13/87	551		Oxidizer	Unknown	Lab pack	Yes	0.15
	03/13/87	551		Flammable	Solid	Lab pack	Yes	0.08
	03/13/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.15
	03/13/87	551		Poison B	Solid	Lab pack	Yes	0.75
	03/13/87	551		ORM-E	Liquid	Lab pack	Yes	0.25
	03/13/87	551	Nitric Acid	Oxidizer	Unknown	Lab pack	Yes	0.08
	03/13/87	551	Acetic Anhydride	Corrosive	Liquid	Lab pack	Yes	0.03
	03/13/87	551	Bromine	Corrosive	Unknown	Lab pack	Yes	0.03
	03/13/87	551		Poison B	Solid	Lab pack	Yes	0.05
	03/13/87	551		Corrosive	Liquid	Lab pack	Yes	0.15
	03/13/87	551		Poison B	Liquid	Lab pack	Yes	0.15
	03/13/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	03/13/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	03/13/87	551		Poison B	Liquid	Lab pack	Yes	0.25
	03/13/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.15
	03/13/87	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.08

								QUARTER TOTAL 30.08
								=====
2	04/02/87	551		Corrosive	Liquid	Lab pack	Yes	0.01
	04/02/87	551		Flammable	Liquid	Lab pack	Yes	0.05
	04/02/87	551		Flammable	Unknown	Lab pack	Yes	0.13
	04/02/87	551		Corrosive	Solid	Lab pack	Yes	0.03
	04/02/87	551		Flammable	Liquid	Lab pack	Yes	0.01
	04/06/87	551		Poison B	Solid	Lab pack	Yes	0.50
	04/06/87	551		Oxidizer	Unknown	Lab pack	Yes	0.25
	04/06/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.05
	04/06/87	551		Flammable	Liquid	Lab pack	Yes	0.50
	04/06/87	551		Flammable	Solid	Lab pack	Yes	0.15
	04/06/87	551		Corrosive	Solid	Lab pack	Yes	0.65
	04/06/87	551	Bromine	Corrosive	Unknown	Lab pack	Yes	0.03
	04/06/87	551		ORM-E	Liquid	Lab pack	Yes	0.25
	04/08/87	551		Corrosive	Solid	Lab pack	No	0.35
	04/08/87	551		Flammable	Solid	Lab pack	Yes	0.15

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Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
2	04/08/87	551		Poison B	Liquid	Lab pack	Yes	0.25
	04/08/87	551		Oxidizer	Unknown	Lab pack	Yes	0.25
	04/08/87	551		Poison B	Solid	Lab pack	Yes	1.50
	04/08/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.33
	04/08/87	551		Flammable	Liquid	Lab pack	Yes	0.15
	04/08/87	551		Poison B	Liquid	Lab pack	Yes	0.23
	04/09/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.40
	04/09/87	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.03
	04/09/87	551	Nitric acid	Oxidizer	Liquid	Lab pack	Yes	0.07
	04/09/87	551		Oxidizer	Unknown	Lab pack	Yes	0.07
	04/09/87	551		Poison B	Solid	Lab pack	Yes	0.50
	04/09/87	551		Poison B	Liquid	Lab pack	Yes	0.50
	04/09/87	551		Flammable	Liquid	Lab pack	Yes	2.00
	04/09/87	551		Flammable	Liquid	Lab pack	Yes	0.15
	04/09/87	551		ORM-E	Liquid	Lab pack	Yes	0.25
	04/09/87	711	Cyanide	Poison B	Unknown	Lab pack	Yes	0.25
	04/29/87	211		ORM-A	Unknown	Lab pack	Yes	0.25
	04/29/87	214		Flammable	Liquid	Lab pack	Yes	4.95
	04/29/87	352	Phenol	Poison B	Unknown	Lab pack	Yes	0.50
	04/29/87	551		Poison B	Liquid	Lab pack	Yes	1.00
	04/29/87	551		Corrosive	Solid	Lab pack	Yes	0.15
	04/29/87	551		Flammable	Liquid	Lab pack	Yes	0.48
	04/29/87	551		Poison B	Solid	Lab pack	Yes	0.75
	04/29/87	551	Acetic anhydride	Corrosive	Liquid	Lab pack	Yes	0.50
	04/29/87	551		Oxidizer	Unknown	Lab pack	Yes	0.15
	04/29/87	551		Corrosive	Liquid	Lab pack	Yes	0.15
	04/29/87	551	Magnesium	Flammable	Solid	Lab pack	Yes	0.03
	04/29/87	551		Flammable	Solid	Lab pack	Yes	0.05
	04/29/87	551	Nitric Acid	Oxidizer	Liquid	Lab pack	Yes	0.15
	04/29/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.50
	04/29/87	551		ORM-E	Solid	Lab pack	Yes	0.05
	05/07/87	181		ORM-E	Solid	Lab pack	Yes	0.25
	05/07/87	213		Flammable	Liquid	Lab pack	Yes	0.18
	05/07/87	214		Flammable	Liquid	Lab pack	Yes	0.25
	05/07/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	05/07/87	551		Corrosive	Liquid	Lab pack	Yes	0.16
	05/07/87	551		Poison B	Liquid	Lab pack	Yes	0.23
	05/14/87	261	Polychlorinated biphenyls	ORM-E	Liquid	Lab pack	No	0.50
	05/14/87	261	Polychlorinated biphenyls	ORM-E	Liquid	Lab pack	No	3.00
	05/14/87	261	Polychlorinated biphenyls	ORM-E	Liquid	Lab pack	No	2.50
	05/15/87	551	Cyanide	Poison B	Unknown	Lab pack	Yes	0.15
	05/18/87	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.08
	05/18/87	551		Poison B	Solid	Lab pack	Yes	0.50
	05/18/87	551	Acid	Corrosive	Solid	Lab pack	Yes	0.50
	05/18/87	551		Oxidizer	Solid	Lab pack	Yes	0.02
	05/18/87	551		Poison B	Solid	Lab pack	Yes	0.25
	05/20/87	551		Flammable	Liquid	Lab pack	Yes	0.08
	05/20/87	551		Corrosive	Solid	Lab pack	Yes	0.08
	05/20/87	551		Flammable	Liquid	Lab pack	Yes	0.05
	05/20/87	551		Poison B	Solid	Lab pack	Yes	0.50

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2	05/20/87	551		Oxidizer	Solid	Lab pack	Yes	0.05
	05/20/87	551		Poison B	Liquid	Lab pack	Yes	0.25
	05/20/87	551		Flammable	Solid	Lab pack	Yes	0.05
	05/20/87	551		Oxidizer	Unknown	Lab pack	Yes	0.15
	05/20/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.23
	05/20/87	551		ORM-E	Solid	Lab pack	Yes	0.25
	05/20/87	551	Phosphorus amorphus red	Flammable	Solid	Lab pack	Yes	0.05
	05/20/87	551		Corrosive	Solid	Lab pack	Yes	0.13
	05/20/87	551		Poison B	Solid	Lab pack	Yes	0.65
	05/28/87	512		Flammable	Liquid	Lab pack	Yes	0.17
	06/08/87	551	Paint	Flammable	Liquid	Bulk	Yes	0.30
	06/17/87	551	Cyanide	Poison B	Unknown	Lab pack	Yes	0.05
	06/17/87	551	Nitric acid	Oxidizer	Unknown	Lab pack	Yes	0.05
	06/17/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.30
	06/17/87	551		Oxidizer	Liquid	Lab pack	Yes	0.15
	06/17/87	551		Corrosive	Solid	Lab pack	Yes	0.40
	06/17/87	551		Poison B	Solid	Lab pack	Yes	0.75
	06/17/87	551		Poison B	Liquid	Lab pack	Yes	0.50
	06/17/87	551		Flammable	Solid	Lab pack	Yes	0.08
	06/17/87	551	Bromine	Corrosive	Unknown	Lab pack	Yes	0.03
	06/17/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	06/17/87	551		ORM-E	Solid	Lab pack	Yes	0.75
	06/22/87	551		Poison B	Solid	Lab pack	Yes	0.75
	06/22/87	551		Flammable	Solid	Lab pack	Yes	0.08
	06/22/87	551		Oxidizer	Unknown	Lab pack	Yes	0.15
	06/22/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.30
	06/22/87	551		Flammable	Liquid	Lab pack	Yes	0.50
	06/22/87	551		Flammable	Liquid	Lab pack	Yes	0.50
	06/22/87	551		ORM-E	Solid	Lab pack	Yes	0.25
	06/22/87	551		Corrosive	Solid	Lab pack	Yes	0.90
	06/22/87	551		Corrosive	Liquid	Lab pack	Yes	0.08
	06/22/87	551	Bromine	Corrosive	Unknown	Lab pack	Yes	0.03
	06/22/87	551	Acetic anhydride	Corrosive	Liquid	Lab pack	Yes	0.05
	06/22/87	551	Magnesium	Flammable	Solid	Lab pack	Yes	0.05
	06/22/87	551		Poison B	Solid	Lab pack	Yes	1.65
	06/22/87	551		Flammable	Solid	Lab pack	Yes	0.08
	06/22/87	551		Poison B	Liquid	Lab pack	Yes	0.25
	06/25/87	214		Flammable	Liquid	Bulk	Yes	5.45
	06/25/87	551	Lead, Murcury	Poison B	Solid	Lab pack	Yes	0.25
								QUARTER TOTAL 46.14

3	07/06/87	551		Poison B	Solid	Lab pack	Yes	0.25
	07/06/87	551	Acid	Corrosive	Unknown	Lab pack	Yes	0.08
	07/06/87	551	Nitric acid	Oxidizer	Unknown	Lab pack	Yes	0.15
	07/06/87	551	Cyanide	Poison B	Solid	Lab pack	Yes	0.08
	07/06/87	551	Ferric chloride	Corrosive	Liquid	Lab pack	Yes	0.15
	07/06/87	551		Oxidizer	Unknown	Lab pack	Yes	0.05

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Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
3	07/06/87	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.08
	07/06/87	551	Mercury metallic	ORM-B	Liquid	Lab pack	Yes	0.25
	07/06/87	551		ORM-E	Solid	Lab pack	Yes	0.19
	07/06/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.20
	07/06/87	551	Cyanide	Poison B	Unknown	Lab pack	Yes	0.05
	07/06/87	551		Flammable	Solid	Lab pack	Yes	0.05
	07/06/87	551		Flammable	Liquid	Lab pack	Yes	0.08
	07/06/87	551		Flammable	Liquid	Lab pack	Yes	0.15
	07/07/87	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.15
	07/07/87	551		Poison B	Solid	Lab pack	Yes	0.50
	07/07/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	07/07/87	551		Oxidizer	Unknown	Lab pack	Yes	0.05
	07/07/87	551	Dimethyl sulfide	Flammable	Liquid	Lab pack	Yes	0.05
	07/07/87	551		ORM-E	Solid	Lab pack	Yes	0.25
	07/07/87	551	Phosphoric anhydride	Corrosive	Solid	Lab pack	Yes	0.03
	07/07/87	551		Flammable	Solid	Lab pack	Yes	0.03
	07/07/87	551		Corrosive	Solid	Lab pack	Yes	0.15
	07/08/87	551	Ammonium Sulfide	Flammable	Liquid	Lab pack	Yes	0.05
	07/08/87	551		Flammable	Liquid	Lab pack	Yes	0.15
	07/14/87	551		Poison B	Solid	Lab pack	Yes	1.00
	07/14/87	551		Corrosive	Solid	Lab pack	Yes	0.20
	07/14/87	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.15
	07/14/87	551		Poison B	Liquid	Lab pack	Yes	0.25
	07/14/87	551	Hydrazine	Corrosive	Liquid	Lab pack	Yes	0.05
	07/14/87	551		ORM-E	Liquid	Lab pack	Yes	0.50
	07/14/87	551	Paint	Flammable	Liquid	Bulk	Yes	1.00
	07/14/87	551		Flammable	Liquid	Bulk	Yes	0.20
	07/14/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	07/14/87	551		Oxidizer	Liquid	Lab pack	Yes	0.08
	07/14/87	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.08
	07/14/87	551		ORM-E	Solid	Lab pack	Yes	1.00
	07/22/87	181	Caustic Soda	Corrosive	Solid	Bulk	Yes	0.25
	07/22/87	214		Flammable	Liquid	Bulk	Yes	1.73
	07/22/87	214	Paint	Flammable	Liquid	Bulk	Yes	2.72
	07/22/87	322		ORM-E	Solid	Lab pack	Yes	0.50
	07/22/87	512	Paint	Flammable	Unknown	Lab pack	Yes	0.25
	07/28/87	214	Xylene	Flammable	Liquid	Bulk	Yes	0.82
	07/28/87	551	Cyanide	Poison B	Unknown	Lab pack	Yes	0.15
	07/28/87	551		Poison B	Liquid	Lab pack	Yes	0.50
	07/28/87	551	Alkaline	Corrosive	Liquid	Lab pack	Yes	0.23
	07/28/87	551	Hydrazine anhydrous	Corrosive	Solid	Lab pack	Yes	0.03
	07/28/87	551		Poison B	Solid	Lab pack	Yes	0.33
	07/28/87	551		ORM-A	Solid	Lab pack	Yes	0.06
	07/28/87	551		Corrosive	Solid	Lab pack	Yes	0.15
	07/28/87	551		Flammable	Solid	Lab pack	Yes	0.03
	07/28/87	551		ORM-E	Solid	Lab pack	Yes	0.75
	07/28/87	551		Flammable	Liquid	Lab pack	Yes	1.25
	07/28/87	551		Poison B	Solid	Lab pack	Yes	0.25
	07/28/87	551		Flammable	Liquid	Lab pack	Yes	0.40
	07/28/87	551	Phosphorus pentoxide	Corrosive	Solid	Lab pack	Yes	0.30

RALPH STONE AND COMPANY, INC.
LARGE UNIVERSITY
WASTE CHEMICAL
MANIFEST DATA

Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)

3	07/28/87	551		Oxidizer	Unknown	Lab pack	Yes	0.25
	07/28/87	551		Poison B	Liquid	Lab pack	Yes	0.15
	08/17/87	214		Flammable	Liquid	Bulk	No	2.97
	09/02/87	151		Poison B	Liquid	Lab pack	Yes	0.25
	09/02/87	151		Poison B	Solid	Lab pack	Yes	0.58
	09/02/87	151		Corrosive	Liquid	Lab pack	Yes	0.75
	09/02/87	151		ORM-E	Solid	Lab pack	Yes	1.00
	09/02/87	151		Poison B	Solid	Lab pack	Yes	0.25
	09/02/87	214		Flammable	Liquid	Bulk	Yes	0.57
	09/02/87	214	Paint	Flammable	Liquid	Bulk	Yes	0.54
	09/02/87	352	Formalin	ORM-A	Unknown	Lab pack	Yes	1.75
	09/02/87	551		Flammable	Liquid	Lab pack	No	0.01
	09/02/87	551	Cyanide	Poison B	Liquid	Lab pack	No	0.08
	09/02/87	551		Water reactive	Solid	Lab pack	No	0.03
	09/02/87	551		Oxidizer	Unknown	Lab pack	Yes	0.08
	09/02/87	551	Picric acid	Flammable	Solid	Lab pack	No	0.01
	09/02/87	551		Flammable	Solid	Lab pack	No	0.01
	09/02/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	09/02/87	551	Methyl hydrazine	Flammable	Liquid	Lab pack	Yes	0.03
	09/02/87	551	Phosphorus white	Flammable	Liquid	Lab pack	No	0.01
	09/02/87	551	Sodium azide	Poison B	Unknown	Lab pack	No	0.01
	09/02/87	551		Corrosive	Liquid	Lab pack	Yes	0.15
	09/02/87	551	Phosphoric anhydride	Corrosive	Unknown	Lab pack	Yes	0.03
	09/14/87	214	Solvents	Flammable	Liquid	Bulk	Yes	1.08
	09/14/87	291	Paint	Flammable	Liquid	Lab pack	Yes	0.12
	09/14/87	291	Paint	Flammable	Liquid	Bulk	Yes	0.30
	09/14/87	291	Paint	Flammable	Liquid	Lab pack	Yes	0.75
	09/14/87	551		Corrosive	Solid	Lab pack	Yes	0.45
	09/14/87	551	Hydrazine	Corrosive	Solid	Lab pack	Yes	0.03
	09/14/87	551		Corrosive	Solid	Lab pack	Yes	0.03
	09/14/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	09/14/87	551		Poison B	Liquid	Lab pack	Yes	0.08
	09/14/87	551		Poison B	Solid	Lab pack	Yes	0.08
	09/14/87	551		Poison B	Solid	Lab pack	Yes	0.25
	09/14/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	09/14/87	551	Charcoal	Flammable	Solid	Lab pack	Yes	0.05
	09/14/87	551		Corrosive	Solid	Lab pack	Yes	0.25
	09/14/87	551	Cyanide	Poison B	Unknown	Lab pack	Yes	0.15

QUARTER TOTAL								32.81

4	10/05/87	214	Solvent	Flammable	Liquid	Bulk	Yes	1.36
	10/05/87	551	Calcium hypochlorite	Oxidizer	Liquid	Lab pack	Yes	0.08
	10/05/87	551		Corrosive	Liquid	Lab pack	Yes	0.25
	10/05/87	551		Corrosive	Solid	Lab pack	Yes	0.15
	10/05/87	551		Water reactive	Solid	Lab pack	Yes	0.25
	10/05/87	551		Flammable	Liquid	Lab pack	Yes	0.05
	10/05/87	551	Chlorosulfonic acid	Corrosive	Liquid	Lab pack	Yes	0.05

RALPH STONE AND COMPANY, INC.
LARGE UNIVERSITY
WASTE CHEMICAL
MANIFEST DATA

Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
4	10/05/87	551	Sodium peroxide	Oxidizer	Liquid	Lab pack	Yes	0.03
	10/05/87	551	Phosgene	Poison B	Liquid	Lab pack	Yes	0.08
	10/05/87	551		Oxidizer	Liquid	Lab pack	Yes	0.03
	10/05/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	10/05/87	551		ORM-E	Liquid	Lab pack	Yes	0.05
	10/26/87	214	Paint	Flammable	Liquid	Bulk	Yes	0.27
	10/26/87	214		Flammable	Liquid	Bulk	Yes	0.27
	10/26/87	343	Formalin	ORM-A	Liquid	Bulk	Yes	0.54
	10/26/87	551	Alkaline	Corrosive	Liquid	Lab pack	No	0.08
	10/26/87	551		Poison B	Solid	Lab pack	No	0.50
	10/26/87	551		Corrosive	Solid	Lab pack	No	0.08
	10/26/87	551		Poison B	Liquid	Lab pack	No	0.40
	10/26/87	551	Magnesium	Flammable	Liquid	Lab pack	No	0.03
	10/26/87	551	Paint	Flammable	Liquid	Lab pack	No	1.50
	10/26/87	551	Lithium metal	Flammable	Liquid	Lab pack	Yes	0.01
	10/26/87	551		Oxidizer	Liquid	Lab pack	No	0.15
	10/26/87	551	Acetic anhydride	Corrosive	Liquid	Lab pack	No	0.05
	10/26/87	551	Phosphoric anhydride	Corrosive	Liquid	Lab pack	No	0.03
	10/26/87	551		Flammable	Liquid	Lab pack	Yes	0.25

QUARTER TOTAL 6.79

QUESTIONNAIRE FOR MEETING WITH GEOLOGY DEPARTMENT AT
LARGE UNIVERSITY

Attendees:

- 1) Describe type of chemical usage in department.
- 2) Where are chemicals stored and/or dispersed from.
- 3) What kinds of wastes are generated? Are there any wastes from undergraduate work?
- 4) Has there been an increased use of instrumentation in chemical based processes? Has this instrumentation reduced the quantity of chemicals used?
- 5) Is it feasible to reduce the input of amount of chemicals used in specific chemical based processes, thereby reducing the amounts of waste generated? If so please describe.
- 7) Can wastes be treated/destroyed as part of the process or procedures?
- 8) Can less hazardous chemicals be substituted in chemical based processes?
- 9) What recommendations do you have for waste reduction in your department?

QUESTIONS FOR BIOLOGY DEPARTMENT ON CHEMICAL USAGE AT
LARGE UNIVERSITY

Attendees:

- 1) Describe your position with the Biology Department.
- 2) Describe the types of chemicals used in undergraduate biology labs, graduate labs?
- 3) Which biology undergraduate and graduate subdivision generated the most amount/most toxic waste?
- 4) Where are chemicals stored and dispersed from?
- 5) What kinds of wastes are generated from undergraduate lab exercises? From Graduate/Research?
- 6) Has chemical usage changed over the years as a result of increased environmental and safety regulations.
- 7) Has there been an increase in instrumentation in lab exercises? How has this affected chemical usage and waste generation?
- 8) In chemistry there has been more use of "micro-scale" labs which utilize small glassware, which in turn results in less chemicals used. Is this being done in biology? If not, is this approach feasible?
- 9) Can certain waste be treated/destroyed as part of the experimental process?
- 10) Have any waste reduction strategies already been implemented?
- 11) What recommendations could you offer to reduce chemical waste generation in biology labs?

QUESTIONNAIRE FOR ARTS DEPARTMENT ON CHEMICAL USAGE AT
LARGE UNIVERSITY

Attendees:

- 1) What areas/disciplines in the department use chemicals?
- 2) What kinds of chemicals are used in each of these areas?
- 3) What waste streams are generated in each of these areas?
- 4) What changes in chemical usage have occurred in recent years as a result of increased awareness of chemical hazards and environmental issues?
- 5) Is it possible to substitute less toxic/hazardous chemicals (i.e. use of water based paints instead of oil based paints, etc.)?
- 6) Do you have any recommendations, suggestions for other ways to reduce waste generation?

RALPH STONE AND COMPANY, INC.

APPENDIX B

CHEMICAL WASTE GENERATION DATA
FROM AUDIT OF A RESEARCH INSTITUTE

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Partial Listing of Chemicals Stocked
In One of Two Biology Storerooms

	<u>QUANTITY</u>	<u>CONTAINER</u>
ACETIC ACID, GLACIAL, 1 PINT	2	G
ACETIC ACID, GLACIAL, 5 LBS	4	G
ACETIC ANHYDRIDE, 500 ML	2	G
ACETONE, A.R. REAGENT, 1 PINT	8	G
ACETONE ACS REAGENT, EK 13006, 1 GAL	5	G
ACETONE, TECHNICAL GRADE, 1 GAL	2	C
ACETYLCHOLINE CHLORIDE, 25 GRAMS	1	P
ACRYLAMIDE, ELECTROPHORESIS GRADE, 100 GRAMS	1	G
AGAR, BACTO, 1 LB	6	C
B-ALANINE, 100 GRAMS	2	P
ALCIAN BLUE, 8 GX, 10 G	3	G
ALBUMIN, FIXATIVE, MAYERS, 4 Oz.	3	P
ALIZARIN SODIUM SULFONATE, 25 GRAMS	3	G
AMMONIUM HYDROXIDE, 1 PINT	3	G
AMMONIUM HYDROXIDE, A.R., 4 LBS	1	G
AMMONIUM CHLORIDE, GRANULAR, 1 LB A.R.	1	G
AMMONIUM PERSULFATE, 10 GRAMS (ELECTROPH. GRADE)	3	G
AMMONIUM SULFATE, A.R. GRANULAR, 1 LB	1	G
AMMONIUM SULFATE, GRANULAR, 5 LBS	3	G
AMMONIUM SULFATE, ULTRA PURE, 1 KG	2	G
AMPICILLIN, A-6140, 5 GRAMS	3	P
AMPICILLIN TRIHYDRATE, 25 GRAMS, A6140	2	P
L-ASCORBIC ACID, VITAMIN C, 100 GRAMS	1	G
AQUAMOUNT, CLEAR MOUNTING MEDIA, 100 ML	6	G
AQUASOL-2, L.S.C. COCKTAIL, 4 LITRES	2	G
BARBITAL BUFFER, 1 VIAL	12	P
BENZYL ALCOHOL, 500 ML	3	G
BICUCULLINE, 100/MG	1	G
D-BIOTIN, VITAMIN H, 100 MG	3	G
BIS (N,N-METHYLENE-BIS-ACRYLAMIDE) 5 GM, (ELECTR. GR.)	1	G
BONE WAX, ETHICON W-31 G (12 X 2.5 GM PKG/BX)	1	P
BORIC ACID, GRANULAR, 1 LB	5	P
BUFFER SOLUTION, STANDARD, PH4, 1 PT	2	P
BUFFER SOLUTION, STANDARD, PH7, 1 PT	3	P
BUFFER SOLUTION, STANDARD, PH10, 1 PT	2	P
BUTYL ALCOHOL, N, REAGENT, 1 PT	5	G
BUTYL ALCOHOL, N.A.R., 8 PTS	2	G
CACODYLIC ACID, SODIUM SALT, 25 GRAMS	4	G
CAJEPUT OIL (PFS) #C 7517, 25 ML	3	G
CALCIUM CARBONATE, A.R., 1/4 LB (POWDER)	1	P
CALCIUM CHLORIDE ANHYDROUS, 8 MESH, 1#	6	P
CALCIUM PHOSPHATE TRIBASIC, 100 GM	3	P
CARBON TETRACHLORIDE, A.R. 1 PINT	2	G
BACTO CASAMINIO ACID, 1 LB, DIFCO	3	P
CAULK GRIP CEMENT POWDER, IVORY, 1/2#	3	P
CAULK GRIP CEMENT LIQUID, 1/2 PT	4	C
CEDARWOOD OIL FOR HISTOLOGICAL CLEARING, 500 ML	4	G
CEMENT, PERM REBASE AND REPAIR ACRYLIC, TYPE II, CLASS I, CLEAR, POWDER ONLY, #00379, 1 LB	2	P
CEMENT, PERM REBASE AND REPAIR ACRYLIC, TYPE II, CLASS I, CLEAR, LIQUID ONLY, #00384, 1 QT	3	P
CEMENT, STONER-MUDGE PACKAGING COATING & T220 THIN. 1 QT	2	C

	<u>QUANTITY</u>	<u>CONTAINER</u>
CHICAGO BLUE 6B, (PONTAMINE SKY BLUE 6BS) COLOR INDEX:		
24410, 10 GRAMS	1	G
'A CHLORALOSE, 10 G	2	G
CHLORAMPHENICOL, 5 G	2	G
CHLOROFORM, A.R. 1 PINT	2	G
CHLOROFORM ACS REAGENT, EK 13017, 8 PTS	1	G
CHOLINE CHLORIDE, 500 GRAMS	4	G
CHROMIUM POTASSIUM SULFATE, A.R., 1 LB	6	P
CITRIC ACID, GRANULAR, 1 LB	2	P
COBALT CHLORIDE CRYSTALS, A.R., 100 GRAMS	2	P
COOMASSIE BRILLIANT BLUE R, #9120	4	G
CRESYL FAST VIOLET, 10 GRAMS	2	G
CUPRIC SULFATE ANHYDROUS, A.R. 1/4 LB	1	G
CYANOGEN BROMIDE, 100 GRAMS	1	G
CYSTEINE, HYDROCHLORIDE, 5 GRAMS	1	G
CYSTINE, 25 GRAMS	7	G
DEOXYCHOLIC ACID (SODIUM SALT) 25 GM	3	G
"DEPEX" MOUNTING MEDIA, 100 ML	2	G
DEXTROSE, ANHYDROUS, 1 LB	3	P
DEXTROSE, ANHYDROUS, 5 LBS. GRANULAR (GLUCOSE)	2	P
DIALYSIS TUBING 40-MM	1	P
DIALYSIS TUBING 18-MM	OUT	P
DIALYSIS TUBING 25-MM	2	P
DIALYSIS TUBING 45-MM	2	P
O-DIANISIDINE DIHYDROCHLORIDE, D-3252, 15 GRAMS	3	G
1,2-DICHLOROETHANE, REAGENT GRADE, 1 PINT	2	G
1,2-DICHLOROETHANE, SPECTROQUALITY, 500 ML	3	G
DICHLOROMETHANE, 1 PINT	3	G
S/P DICHROL, DICHROMIC ACID, 5 PINTS	5	G
DIMETHYLDICHLOROSILANE, 50 ML	1	G-C
DITHIOTHREITOL, 5 GM (CLELAND'S REAGENT) ELECTR. GR.	OUT	G
DRIERITE, CASO4, INDICATING, 8 MESH, 1 LB	1	G
DRIERITE, 8 MESH, 1 LB, NON-INDICATING	3	G
ETHER FOR ANESTHESIA, 1 LB	4	C
ETHER, A.R., 1 LB	3	C
ETHER ANHYDROUS, A.R., 1 LB	3	C
ETHIDIUM BROMIDE, 1 G	3	G-C
ETHYLENE GLYCOL, A.R., 1 PT	2	G
ETHYLENEDIAMINE TETRACETIC ACID (EDTA) 100 GRAMS	2	P
ETHYL ALCOHOL (DENATURED) 500 ML	7	G
EUKITT MOUNTING MEDIA, FAST HARDENING, 100 ML	3	G
EVAN'S BLUE, 10 GRAMS	2	G
FERRIC AMMONIUM SULFATE, CRYSTALS, 1 LB	OUT	G
FILLING SOLUTION, REFERENCE ELECTRODE, 100 ML	2	P
FLUOROMOUNT, MOUNTING MEDIA, 100 ML	3	G
FORMALDEHYDE SOLUTION, A.R., 1 PINT	1	G
FORMALDEHYDE, 37%, 8 PINTS	1	G
FORMVAR-POLYSCIENCES (POLYVINYL FORMAL) 30 GRAMS	6	P
BASIC FUCHSIN ROSANILIN, 25 GM	3	G
FUCHSIN S (SAUREFUCHSIN), 25 GM	1	G
GELATIN, 1 LB	2	P
GELATIN, TYPE IV; FROM CALF SKIN, 500 GM	1	P
GIEMSA STAIN, 10 GM	4	G
GLUTATHIONE, 1 GRAM	4	G

Abbreviations Found On Bar Diagrams and Graphs

Ex = Explosives

ORM-A = Department of Transportation hazardous materials classification "Other Regulated Material-A". This category includes materials which have "an anesthetic, irritating, noxious, toxic or other similar property and which can cause extreme annoyance or discomfort to passengers and crew in the event of leakage during transportation". Typical chemicals in this category are chlorinated solvents.

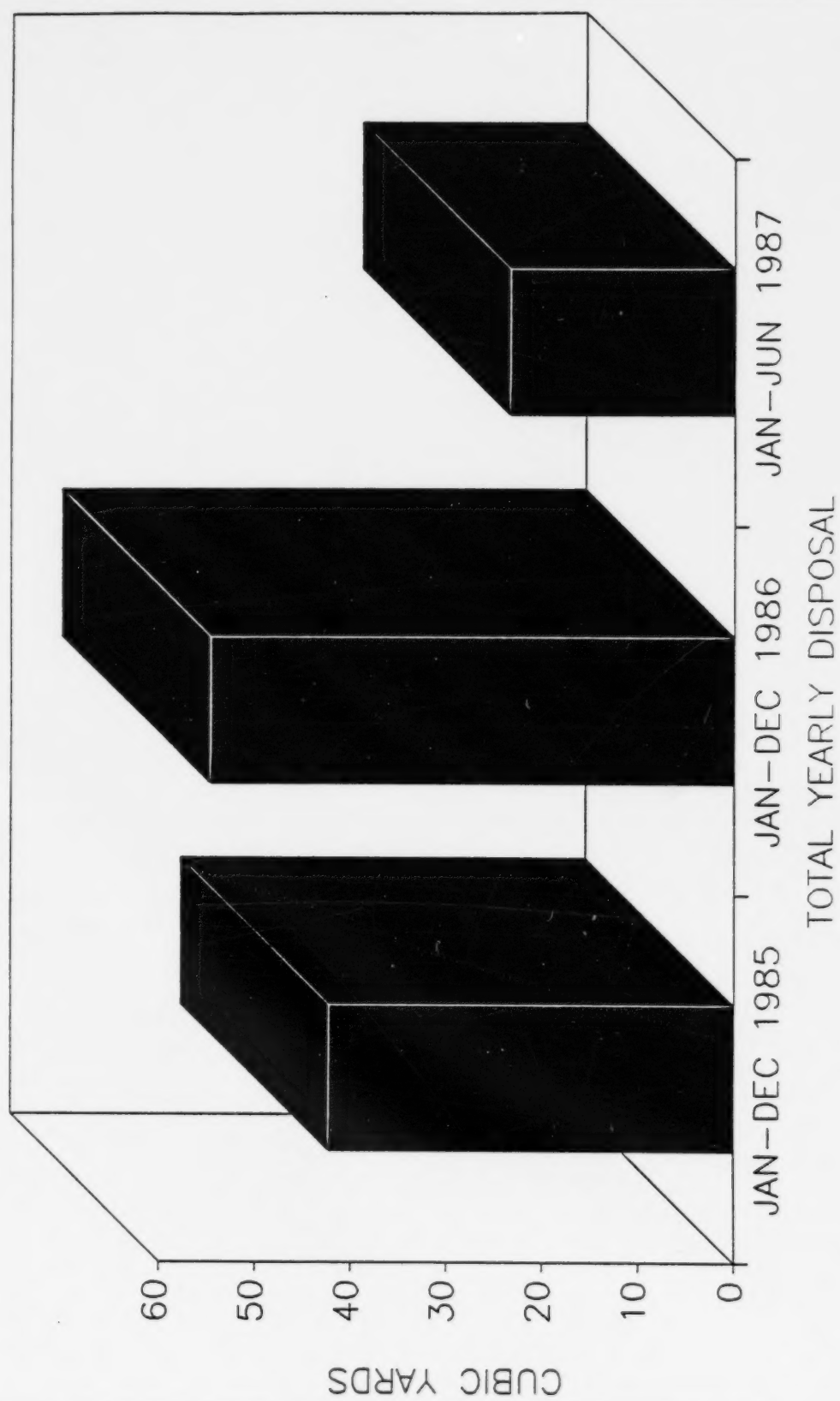
ORM-B = Department of Transportation hazardous materials classification "Other Regulated Material-B". These are chemicals capable of causing significant damage to transport vehicle from leakage during transportation.

ORM-E = Department of Transportation hazardous materials classification "Other Regulated Material-E". This category includes materials that are to included in any other hazard class, but it is subject to appropriate transportation regulations. Materials in this class include hazardous materials and wastes.

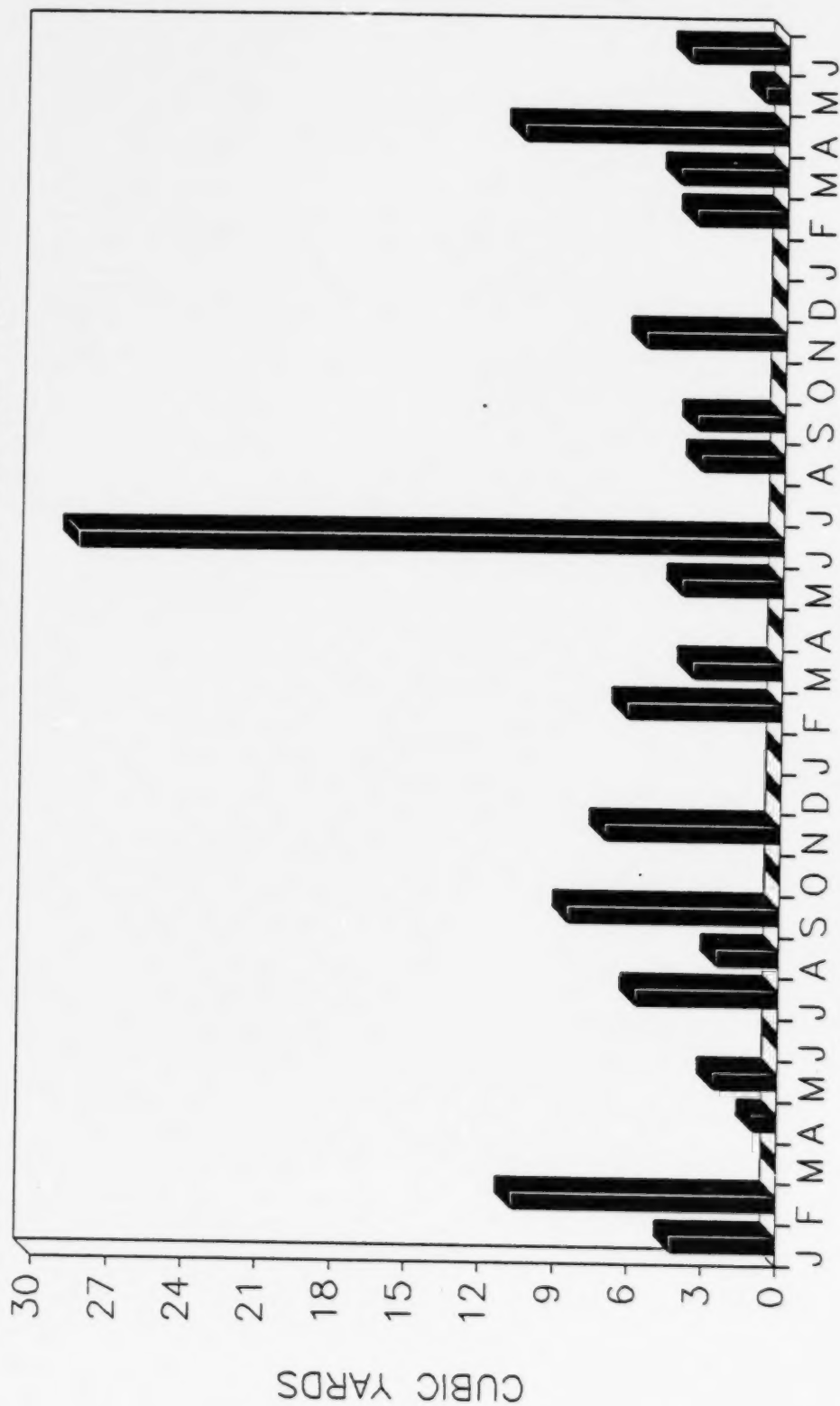
OP = Organic Peroxide waste.

WR = Water Reactive waste.

HAZARDOUS WASTE PER YEAR
DISPOSED OF BY RESEARCH INSTITUTE

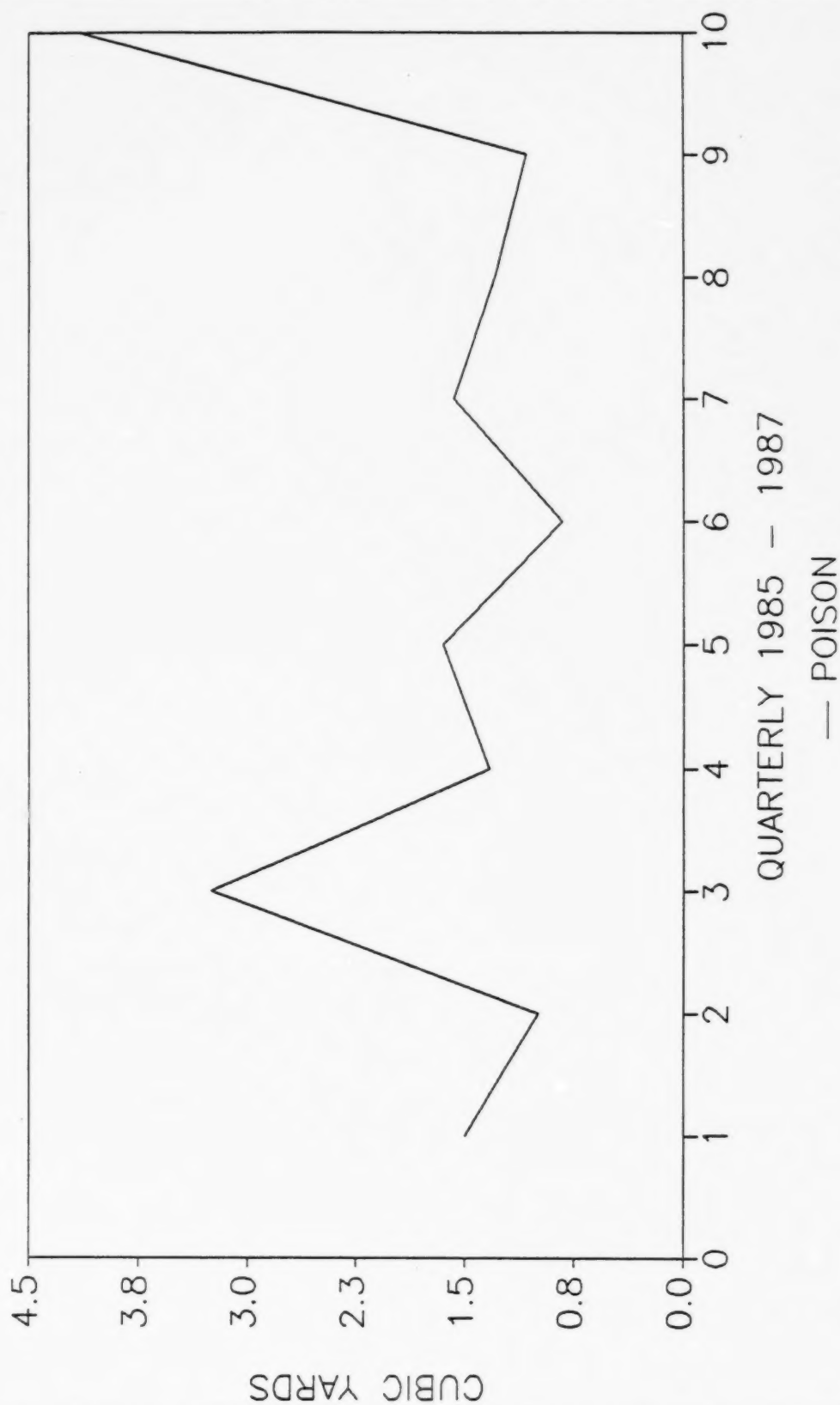


WASTE PER MONTH DISPOSED OF BY RESEARCH INSTITUTE

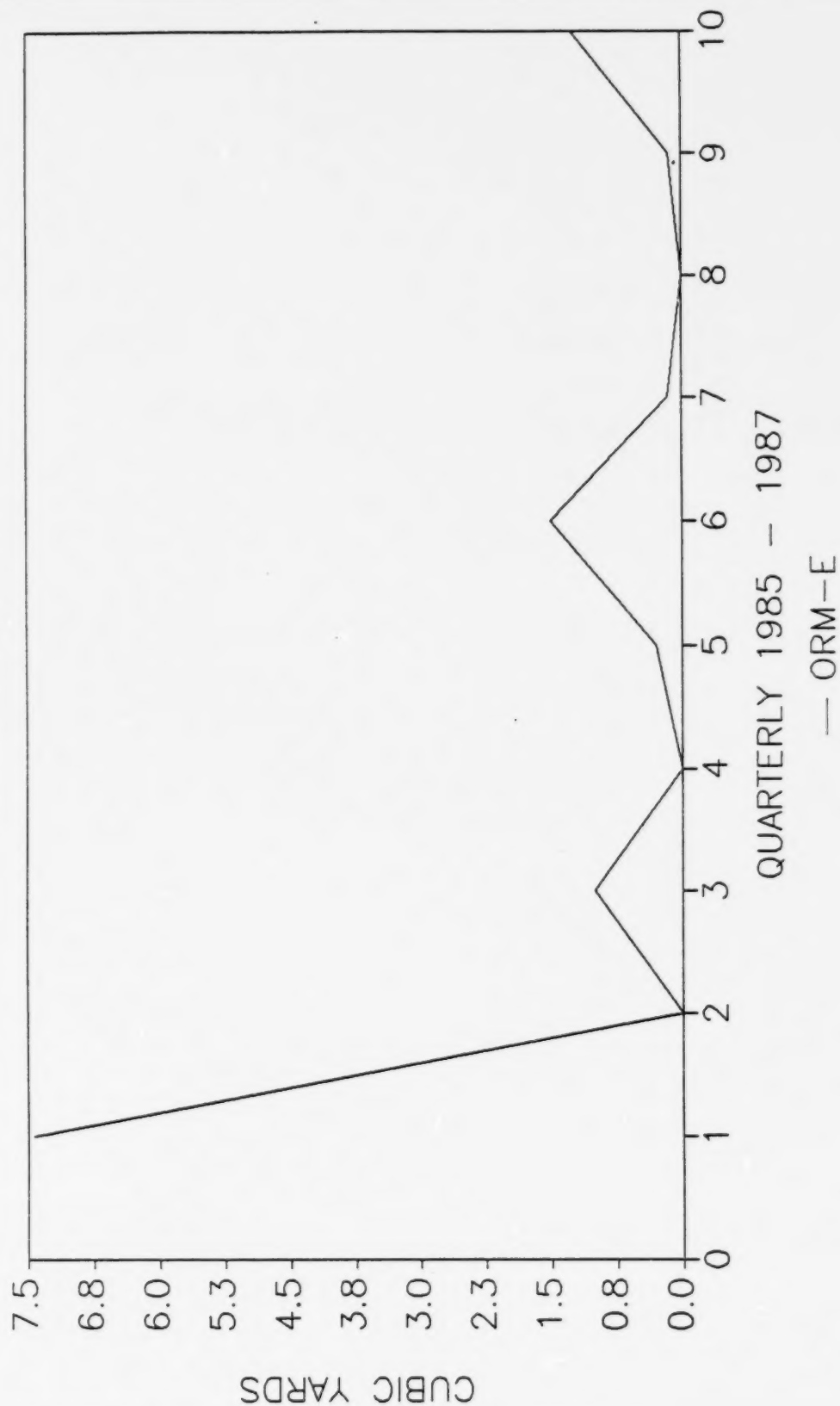


MONTHLY DEC. 1985 - JUNE 1987

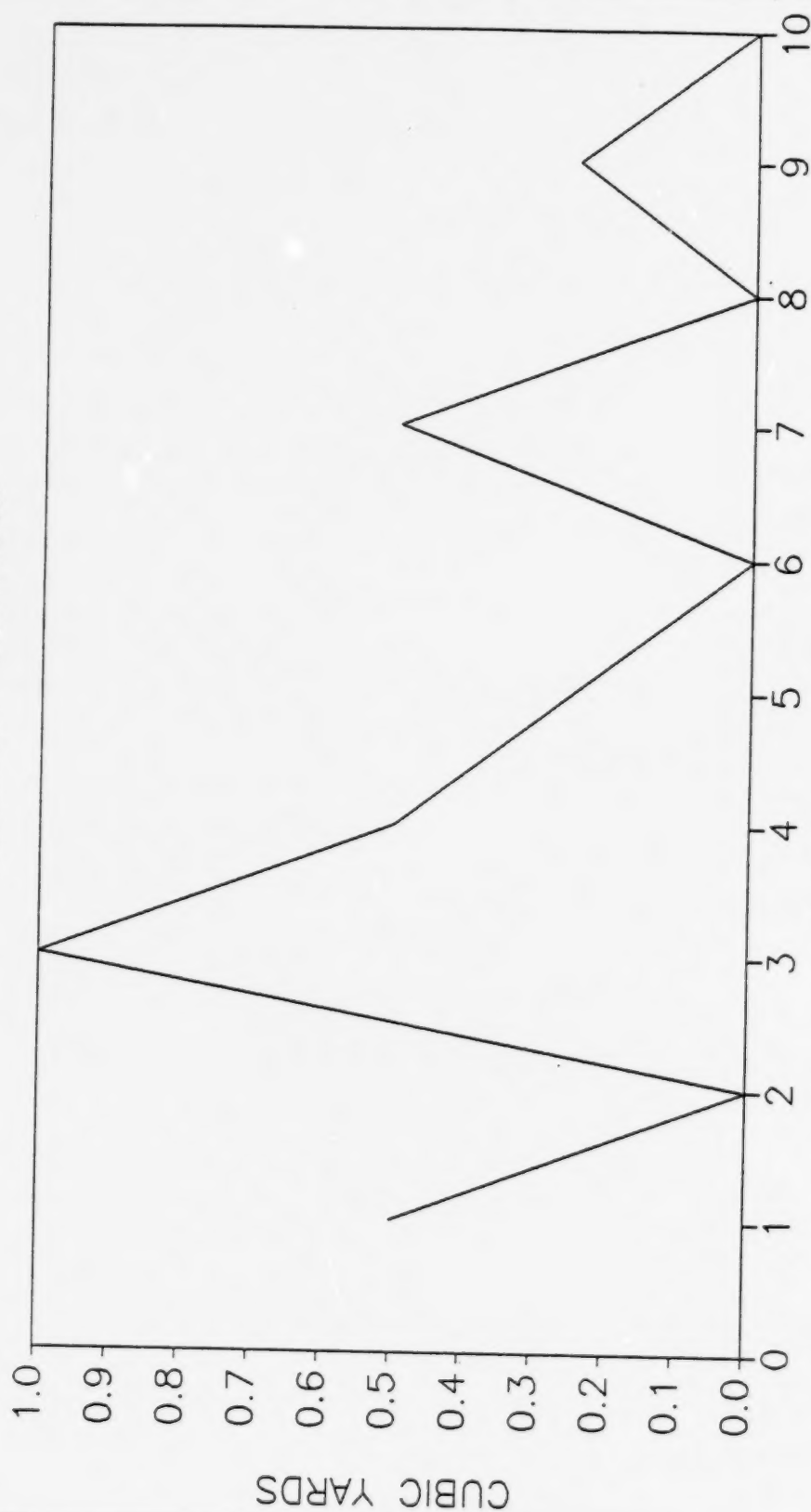
HAZARDOUS WASTE STREAM FOR THE
RESEARCH INSTITUTE



HAZARDOUS WASTE STREAM FOR THE
RESEARCH INSTITUTE

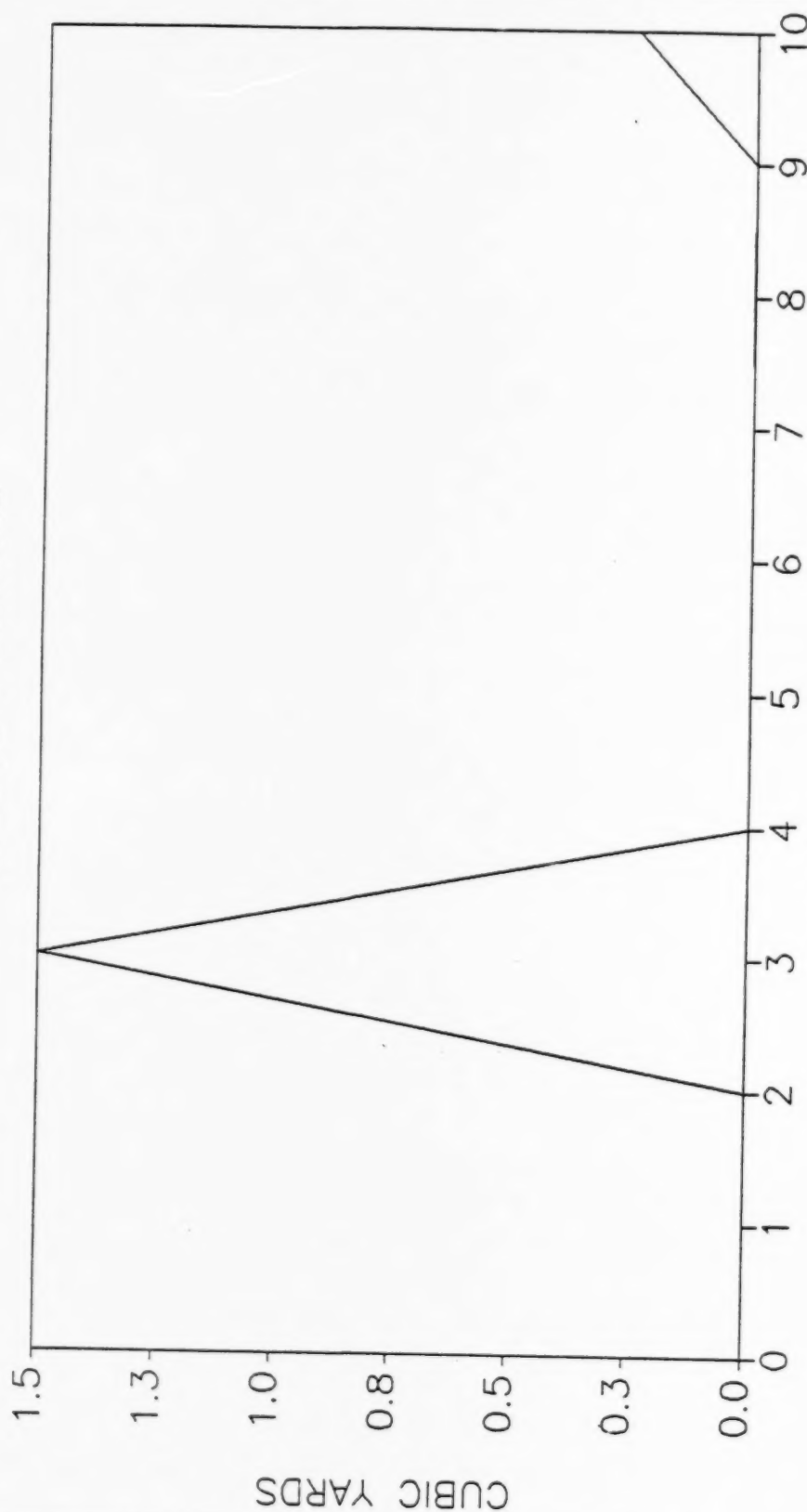


HAZARDOUS WASTE STREAM FOR THE
RESEARCH INSTITUTE

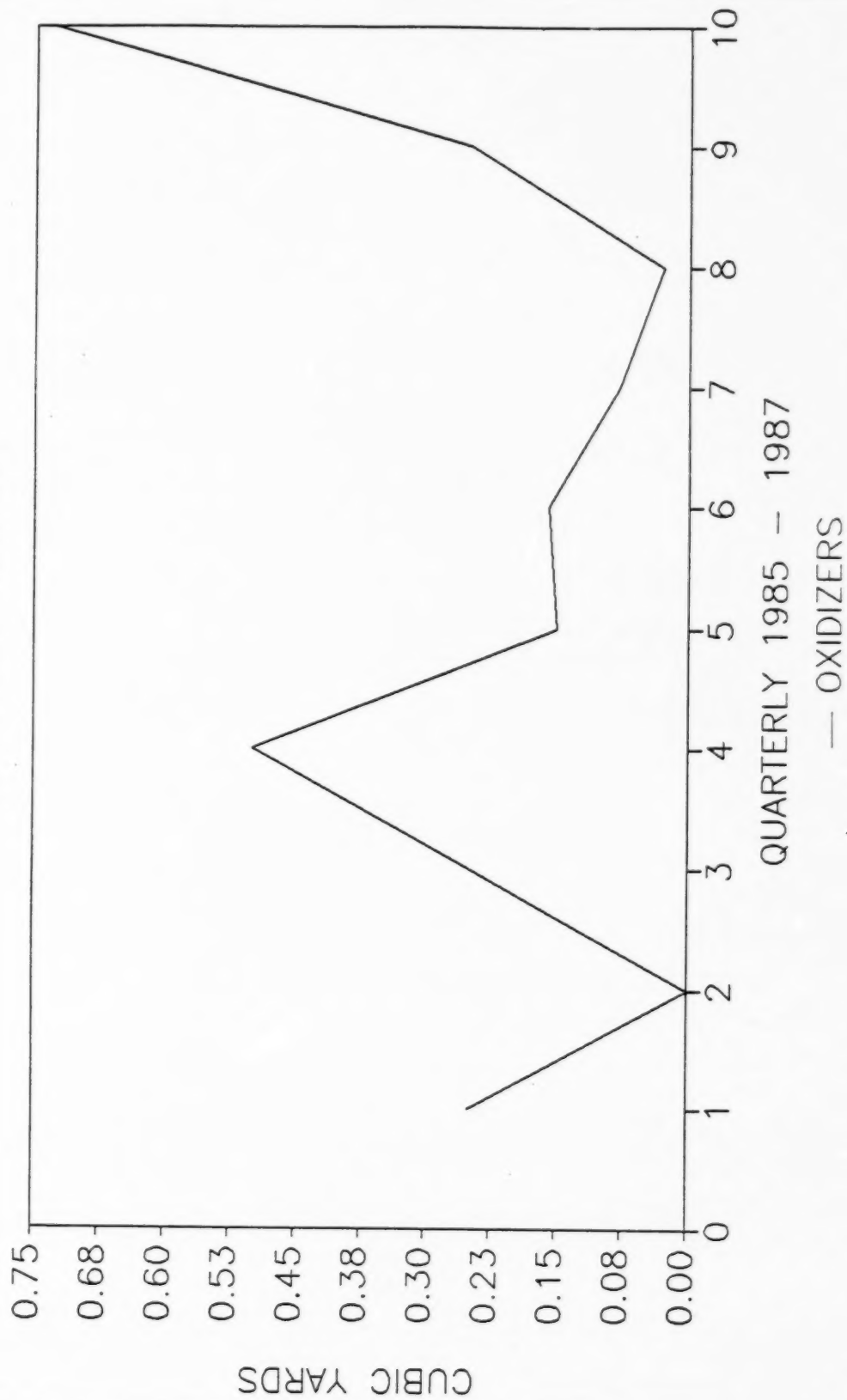


— ORM-A AND ORM-B

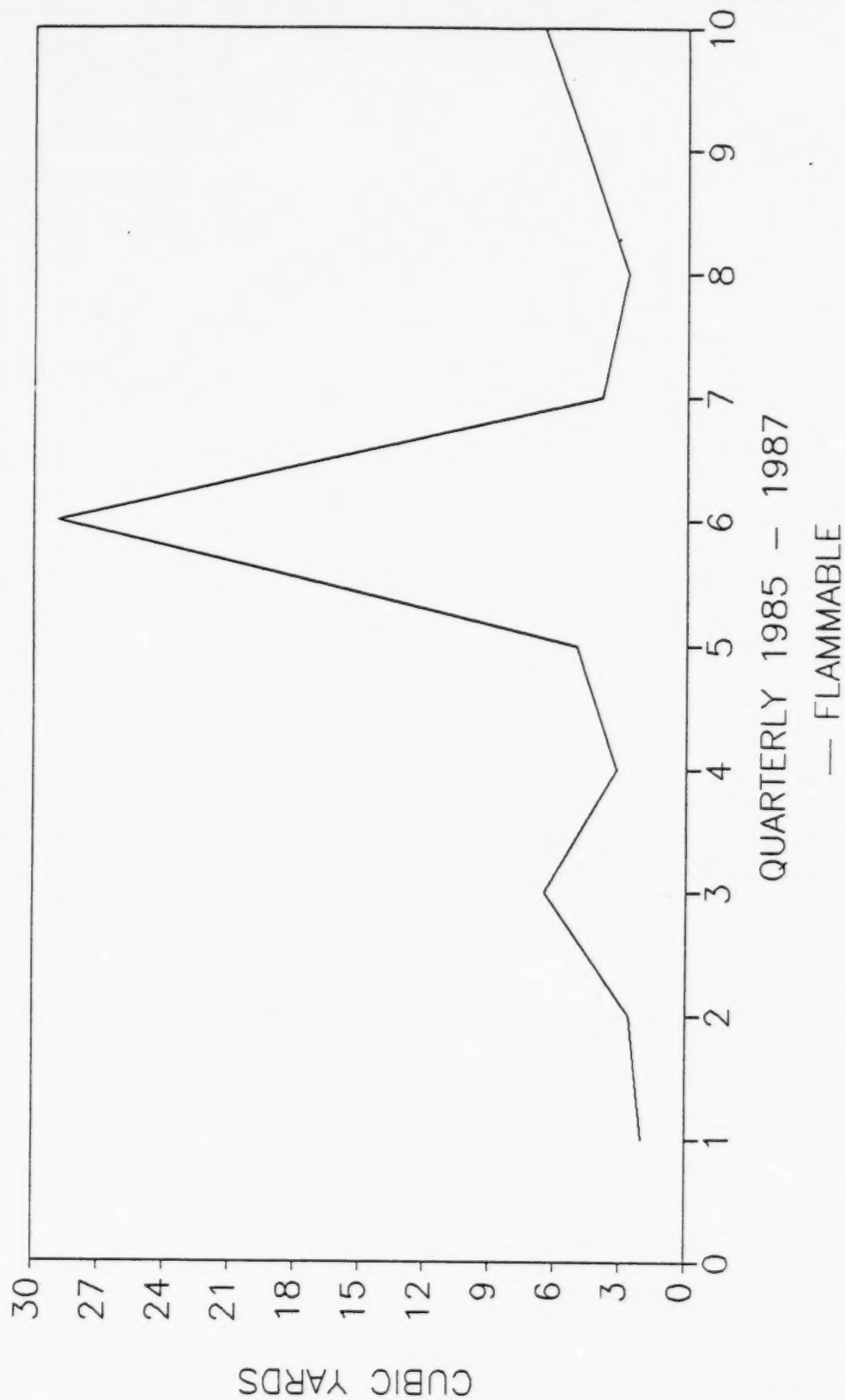
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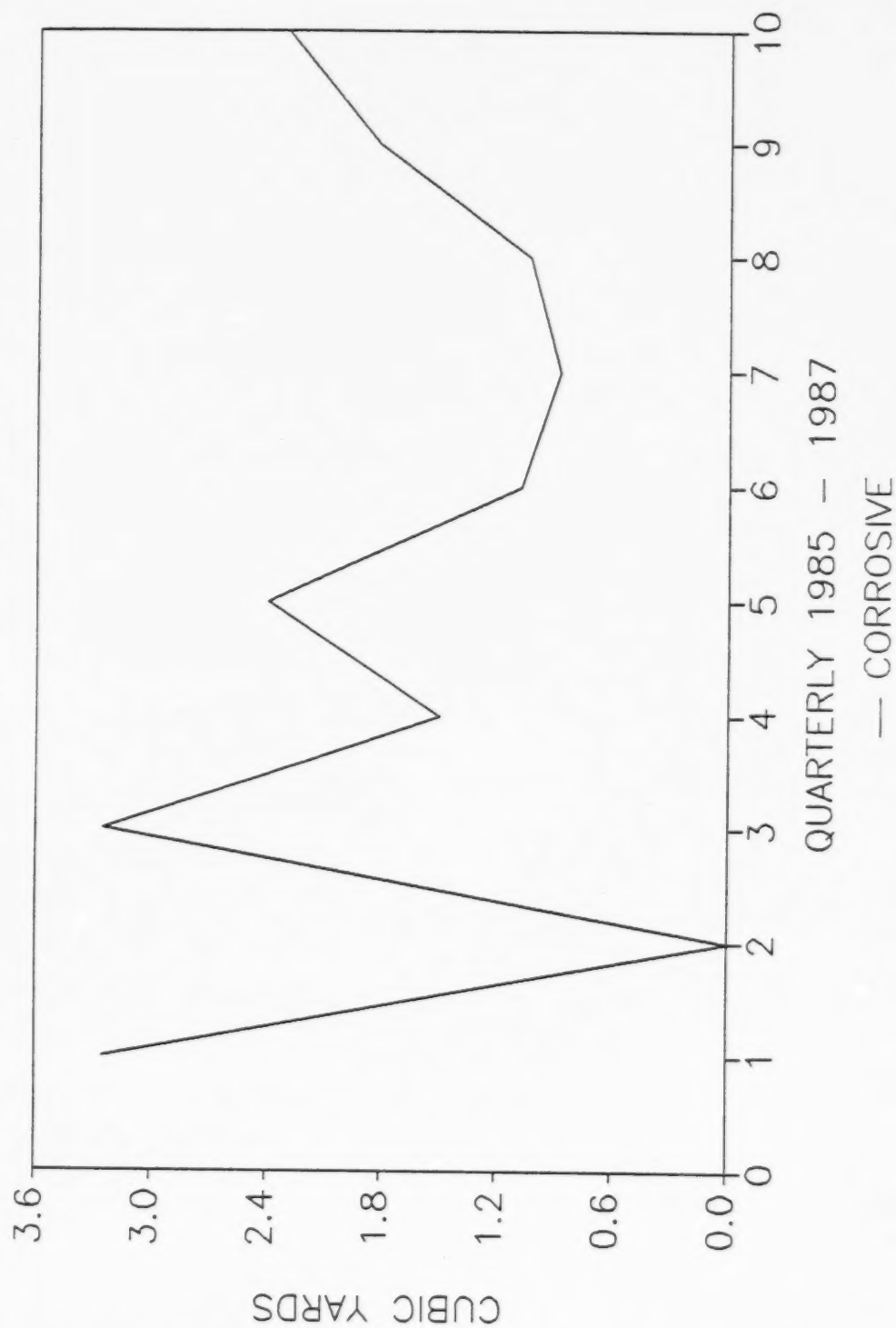
HAZARDOUS WASTE STREAM FOR THE
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HAZARDOUS WASTE STREAM FOR THE
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HAZARDOUS WASTE STREAM FOR THE
RESEARCH INSTITUTE



RALPH STONE AND COMPANY, INC.
RESEARCH FACILITY
WASTE CHEMICAL
MANIFEST DATA

Tr	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
1	01/04/85	551		Poison B	Solid	Lab pack	Yes	0.50
	01/04/85	551	Picric acid	Flammable	Unknown	Lab pack	Yes	0.25
	01/04/85	551		Flammable	Unknown	Lab pack	Yes	0.50
	01/04/85	551		Corrosive	Solid	Lab pack	Yes	0.25
	01/04/85	551		Poison B	Liquid	Lab pack	Yes	0.25
	01/04/85	551		ORM-E	Solid	Lab pack	Yes	0.25
	01/04/85	551	Mercury	ORM-B	Liquid	Lab pack	Yes	0.25
	01/04/85	551		Corrosive	Liquid	Lab pack	Yes	1.75
	01/04/85	551		Oxidizer	Liquid	Lab pack	Yes	0.25
	02/19/85	551		Flammable	Liquid	Lab pack	Yes	1.00
	02/19/85	551		Corrosive	Liquid	Lab pack	Yes	0.25
	02/19/85	551	Mercury	ORM-B	Solid	Lab pack	Yes	0.25
	02/19/85	551		ORM-E	Solid	Lab pack	Yes	1.00
	02/19/85	551		ORM-E	Solid	Lab pack	Yes	6.18
	02/19/85	551	Bromine	Corrosive	Solid	Lab pack	Yes	0.25
	02/19/85	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.25
	02/19/85	551		Corrosive	Solid	Lab pack	Yes	0.25
	02/19/85	551		Flammable	Solid	Lab pack	Yes	0.25
	02/19/85	551		Corrosive	Liquid	Lab pack	Yes	0.25
	02/19/85	551		Poison B	Solid	Lab pack	Yes	0.50
	02/19/85	551		Poison B	Liquid	Lab pack	Yes	0.25

QUARTER TOTAL								14.93
=====								
2	04/18/85	551		Poison B	Solid	Bulk	No	0.75
	04/18/85	551		Poison B	Liquid	Bulk	No	0.25
	05/28/85	214		Flammable	Liquid	Bulk	No	2.60

QUARTER TOTAL								3.60
=====								
3	07/08/85	551		Water Reactive	Solid	Lab pack	Yes	0.25
	07/08/85	551	Picric acid	Flammable	Solid	Lab pack	Yes	0.25
	07/08/85	551		Corrosive	Liquid	Lab pack	Yes	0.25
	07/08/85	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.75
	07/08/85	551	Acetic anhydride	Corrosive	Unknown	Lab pack	Yes	0.75
	07/08/85	551		Poison B	Solid	Lab pack	Yes	1.00
	07/08/85	551		Poison B	Solid	Lab pack	Yes	0.50
	07/08/85	551		Flammable	Liquid	Lab pack	Yes	0.75
	07/08/85	551		Corrosive	Liquid	Lab pack	Yes	0.25
	07/08/85	551		Flammable	Solid	Lab pack	Yes	0.75
	07/10/85	551	Cyanide	Poison B	Solid	Lab pack	Yes	0.25
	08/20/85	213		Flammable	Unknown	Bulk	No	2.00
	08/26/85	261	Polychlorinated biphenyls	ORM-E	Unknown	Bulk	No	0.25
	08/26/85	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.25
	09/16/85	551		Corrosive	Liquid	Lab pack	Yes	0.25
	09/16/85	551		Water Reactive	Solid	Lab pack	Yes	1.25

RALPH STONE AND COMPANY, INC.
RESEARCH FACILITY
WASTE CHEMICAL
MANIFEST DATA

Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
3	09/16/85	551		Corrosive	Liquid	Lab pack	Yes	0.50
	09/16/85	551		Flammable	Solid	Lab pack	Yes	0.25
	09/16/85	551		ORM-E	Solid	Lab pack	Yes	0.75
	09/16/85	551		Poison B	Solid	Lab pack	Yes	0.50
	09/16/85	551		Flammable	Liquid	Lab pack	Yes	0.25
	09/16/85	551		Flammable	Liquid	Lab pack	Yes	1.75
	09/16/85	551	Thionyl chloride	Corrosive	Unknown	Lab pack	Yes	0.25
	09/16/85	551		Corrosive	Unknown	Lab pack	Yes	0.25
	09/16/85	551	Formaldehyde	ORM-A	Liquid	Lab pack	Yes	0.75
	09/16/85	551	Mercury	ORM-B	Liquid	Lab pack	Yes	0.25
	09/16/85	551	Paint	Flammable	Liquid	Lab pack	Yes	0.50
	09/16/85	551		Poison B	Liquid	Lab pack	Yes	0.75
	09/16/85	551		Oxidizer	Solid	Lab pack	Yes	0.25

QUARTER TOTAL								16.75

4	11/05/85	551		Poison B	Liquid	Lab pack	Yes	0.50
	11/05/85	551		Flammable	Liquid	Lab pack	Yes	0.75
	11/05/85	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.25
	11/05/85	551		Poison B	Liquid	Lab pack	Yes	0.50
	11/05/85	551	Mercury	ORM-B	Liquid	Lab pack	Yes	0.50
	11/05/85	551		Corrosive	Solid	Lab pack	Yes	0.50
	11/05/85	551		Oxidizer	Unknown	Lab pack	Yes	0.25
	11/05/85	551		Corrosive	Liquid	Lab pack	Yes	0.25
	11/05/85	551		Flammable	Liquid	Lab pack	Yes	0.50
	11/05/85	551	Nitric acid	Oxidizer	Unknown	Lab pack	Yes	0.25
	11/05/85	551		Flammable	Solid	Lab pack	Yes	0.25
	11/05/85	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.75
	11/13/85	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.08
	11/20/85	213	Hydrocarbon	Flammable	Liquid	Bulk	No	1.70

QUARTER TOTAL								7.03

1	02/17/86	461	Paint	Flammable	Liquid	Lab pack	Yes	1.00
	02/17/86	551	Acid	Corrosive	Liquid	Lab pack	Yes	1.25
	02/17/86	551		Corrosive	Liquid	Lab pack	Yes	1.00
	02/17/86	551	Mercury	ORM-B	Liquid	Lab pack	Yes	0.25
	02/17/86	551	Hydrazine	Flammable	Liquid	Lab pack	Yes	0.25
	02/17/86	551		Poison B	Solid	Lab pack	Yes	0.75
	02/17/86	551		Oxidizer	Unknown	Lab pack	Yes	0.15
	02/17/86	551		Flammable	Liquid	Lab pack	Yes	0.50
	02/17/86	551		Corrosive	Liquid	Lab pack	Yes	0.15
	02/17/86	551		Poison B	Liquid	Lab pack	Yes	0.75
	02/26/86	551	Cyanide	Poison B	Solid	Lab pack	No	0.15
	03/11/86	261	Polychlorinated biphenyls	ORM-E	Solid	Bulk	No	0.30
	03/14/86	214		Flammable	Liquid	Bulk	No	2.80

RALPH STONE AND COMPANY, INC.
RESEARCH FACILITY
WASTE CHEMICAL
MANIFEST DATA

Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
1	03/18/86	461	Paint	Flammable	Liquid	Bulk	No	0.50
QUARTER TOTAL								9.80
=====								
2	05/20/86	551	Acid	Corrosive	Liquid	Lab pack	Yes	1.00
	05/20/86	551		Poison B	Liquid	Lab pack	Yes	0.50
	05/20/86	551	Nitric acid	Oxidizer	Liquid	Lab pack	Yes	0.08
	05/20/86	551		Flammable	Liquid	Lab pack	Yes	0.25
	05/20/86	551		Flammable	Liquid	Lab pack	Yes	0.25
	05/20/86	551		Poison B	Solid	Lab pack	Yes	0.25
	05/20/86	551		Corrosive	Liquid	Lab pack	Yes	0.08
	05/20/86	551		Oxidizer	Solid	Lab pack	Yes	0.08
	05/20/86	551		ORM-E	Liquid	Lab pack	Yes	0.25
	05/20/86	551		ORM-E	Solid	Lab pack	Yes	0.25
	05/20/86	711	Cyanide	Poison B	Solid	Lab pack	Yes	0.08
	05/21/86	261	Polychlorinated biphenyls	ORM-E	Solid	Bulk	No	1.00
	05/21/86	551		Flammable	Liquid	Lab pack	Yes	0.00
	05/21/86	551		Organic Peroxide	Unknown	Lab pack	Yes	0.00
	05/21/86	551	Sulfur trioxide	Corrosive	Unknown	Lab pack	Yes	0.00
	05/21/86	551		ORM-E	Solid	Lab pack	Yes	0.00
	05/21/86	551		Water Reactive	Solid	Lab pack	Yes	0.00
	05/21/86	551	Picric acid	Flammable	Solid	Lab pack	Yes	0.00
	06/19/86	214		Flammable	Liquid	Bulk	No	3.70
	06/23/86	214		Flammable	Liquid	Bulk	No	24.70
QUARTER TOTAL								32.47
=====								
3	08/01/86	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.08
	08/04/86	551		ORM-C	Solid	Bulk	No	0.25
	08/08/86	551		ORM-E	Liquid	Lab pack	Yes	0.08
	08/08/86	551		Corrosive	Liquid	Lab pack	Yes	0.08
	08/08/86	551		Oxidizer	Solid	Lab pack	Yes	0.08
	08/08/86	551		ORM-E	Solid	Lab pack	Yes	0.08
	08/08/86	551		Poison B	Solid	Lab pack	Yes	1.25
	08/08/86	551		Poison B	Liquid	Lab pack	Yes	0.25
	08/08/86	551		Corrosive	Solid	Lab pack	Yes	0.15
	08/08/86	551		Flammable	Liquid	Lab pack	Yes	0.40
	08/08/86	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.50
	08/08/86	551		Corrosive	Liquid	Lab pack	Yes	0.15
	09/10/86	214		Flammable	Liquid	Bulk	No	3.50
QUARTER TOTAL								6.85
=====								

RALPH STONE AND COMPANY, INC.
RESEARCH FACILITY
WASTE CHEMICAL
MANIFEST DATA

Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
4	11/04/86	551		Organic Peroxide	Liquid	Bulk	No	0.00
	11/04/86	551		Flammable	Liquid	Bulk	No	0.00
	11/04/86	551		Flammable	Solid	Bulk	No	0.00
	11/04/86	551		Water Reactive	Solid	Bulk	No	0.00
	11/13/86	151	Acetic anhydride	Corrosive	Liquid	Lab pack	Yes	0.03
	11/13/86	551	Bromide	Corrosive	Unknown	Lab pack	Yes	0.03
	11/13/86	551		Flammable	Liquid	Lab pack	Yes	0.15
	11/13/86	551		Oxidizer	Unknown	Lab pack	Yes	0.03
	11/13/86	551	Mercury	ORM-B	Liquid	Lab pack	Yes	0.50
	11/13/86	551		Poison B	Liquid	Lab pack	Yes	0.25
	11/13/86	551		Corrosive	Liquid	Lab pack	Yes	0.98
	11/13/86	551		Poison B	Solid	Lab pack	Yes	1.05
	11/26/86	214		Flammable	Liquid	Bulk	No	2.60
QUARTER TOTAL								5.62
=====								
1	02/24/87	551	Cyanide	Poison B	Liquid	Lab pack	Yes	0.08
	02/24/87	551		Corrosive	Liquid	Lab pack	Yes	0.08
	02/24/87	551		Flammable	Liquid	Lab pack	Yes	0.25
	02/24/87	551		Corrosive	Liquid	Lab pack	Yes	0.25
	02/24/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	1.25
	02/24/87	551		Poison B	Solid	Lab pack	Yes	0.75
	02/24/87	551		Poison B	Liquid	Lab pack	Yes	0.25
	02/24/87	551		Flammable	Solid	Lab pack	Yes	0.08
	02/24/87	551		ORM-E	Solid	Lab pack	Yes	0.15
	02/24/87	551		Corrosive	Solid	Lab pack	Yes	0.25
	02/24/87	551		Oxidizer	Liquid	Lab pack	Yes	0.25
	03/31/87	214		Flammable	Liquid	Bulk	No	4.30
QUARTER TOTAL								7.94
=====								
2	04/17/87	551	Nitric acid	Oxidizer	Liquid	Lab pack	Yes	0.25
	04/17/87	551		Corrosive	Solid	Lab pack	Yes	0.50
	04/17/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.25
	04/17/87	551		Poison B	Liquid	Lab pack	Yes	0.50
	04/17/87	551		Water Reactive	Solid	Lab pack	Yes	0.25
	04/17/87	551		Corrosive	Liquid	Lab pack	Yes	0.25
	04/17/87	551	Picric acid	Flammable	Solid	Lab pack	Yes	0.25
	04/17/87	551		Flammable	Liquid	Lab pack	Yes	1.00
	04/17/87	551		Flammable	Solid	Lab pack	Yes	0.25
	04/17/87	551		Poison B	Solid	Lab pack	Yes	2.00
	04/17/87	551		Oxidizer	Unknown	Lab pack	Yes	0.25
	04/27/87	181		ORM-E	Solid	Lab pack	Yes	1.00
	04/27/87	181		ORM-E	Liquid	Lab pack	Yes	0.25
	04/27/87	181		ORM-B	Liquid	Lab pack	Yes	0.25

RALPH STONE AND COMPANY, INC.
RESEARCH FACILITY
WASTE CHEMICAL
MANIFEST DATA

Qrt	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
2	04/27/87	551		Oxidizer	Solid	Lab pack	Yes	0.15
	04/27/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.50
	04/27/87	551		Poison B	Solid	Lab pack	Yes	0.25
	04/27/87	551	Cyanide	Poison B	Solid	Lab pack	Yes	0.08
	04/27/87	551	Nitric Acid	Oxidizer	Liquid	Lab pack	Yes	0.08
	04/27/87	551		Corrosive	Solid	Lab pack	Yes	0.23
	04/27/87	551		Poison B	Liquid	Lab pack	Yes	0.50
	04/27/87	551		Corrosive,	Liquid	Lab pack	Yes	0.25
				Alkaline				
	04/27/87	551		Flammable	Liquid	Lab pack	Yes	0.50
	04/27/87	551	Hydrazine	Corrosive	Liquid	Lab pack	Yes	0.08
	04/27/87	551		Poison B	Solid	Lab pack	Yes	0.75
	05/26/87	551	Cyanide	Poison B	Solid	Lab pack	No	0.08
	05/26/87	551		Flammable,	Liquid	Lab pack	No	0.25
				Poisonous				
	05/26/87	551		Flammable	Solid	Lab pack	No	0.08
	05/26/87	551		Flammable,	Liquid	Lab pack	No	0.05
				Poisonous				
	05/26/87	551	NOS	Flammable	Unknown	Lab pack	No	0.50
	06/01/87	551	Acid	Corrosive	Liquid	Lab pack	Yes	0.25
	06/20/87	551	Organic peroxide	Oxidizer	Unknown	Lab pack	Yes	0.00
	06/20/87	551	Dicumyl Peroxide	Organic	Unknown	Lab pack	Yes	0.00
				Peroxide				
	06/20/87	551	Acetyl Peroxide	Organic	Unknown	Lab pack	Yes	0.00
				Peroxide				
	06/20/87	551	2,4 Dinitro phenyl hydrozine	Poison B	Unknown	Lab pack	Yes	0.00
	06/20/87	551	Nitroguanodine	Explosive	Unknown	Lab pack	Yes	0.00
	06/20/87	551	Sodium Peroxide	Oxidizer	Unknown	Lab pack	Yes	0.00
	06/20/87	551	Benzoyl Peroxide	Organic	Unknown	Lab pack	Yes	0.00
				Peroxide				
	06/23/87	214		Flammable	Liquid	Bulk	No	3.70
								QUARTER TOTAL
								15.53
								=====

QUESTIONS FOR MEETING WITH CHEMISTRY DEPARTMENT AT
RESEARCH FACILITY

Attendees:

- 1) How has chemical usage changed over the years as a result of increased environmental regulations?
- 2) Describe the different categories of chemical research being done on campus:
- 3) What are the waste streams being generated in each of these areas of research?
- 4) What categories of undergraduate chemical laboratories are being taught?
- 5) For both graduate and undergraduate labs, is it generally possible to implement microscale experiments to reduce chemical usage and waste generation?
- 6) Describe efforts to substitute less hazardous chemicals in both research and undergraduate labs:
- 7) What other waste reduction methods have been implemented at your research facility?
- 8) Is it possible to treat and/or destroy chemical wastes as part of laboratory experiments?
- 9) How has the increase in the use of instrumentation effected chemical usage and waste generation?
- 10) What other recommendations can you offer for waste reduction?

QUESTIONNAIRE FOR MEETING WITH GEOLOGY DEPARTMENT AT
RESEARCH FACILITY

Attendees:

- 1) Describe type of chemical usage in department.
- 2) Where are chemicals stored and/or dispersed from.
- 3) What kinds of wastes are generated? Are there any wastes from undergraduate work?
- 4) Has there been an increased use of instrumentation in chemical based processes? Has this instrumentation reduced the quantity of chemicals used?
- 5) Is it feasible to reduce the input of amount of chemicals used in specific chemical based processes, thereby reducing the amounts of waste generated? If so please describe.
- 7) Can wastes be treated/destroyed as part of the process or procedures?
- 8) Can less hazardous chemicals be substituted in chemical based processes?
- 9) What recommendations do you have for waste reduction in your department?

RALPH STONE AND COMPANY, INC.

APPENDIX C

CHEMICAL WASTE GENERATION DATA
FROM AUDIT OF A
SMALL, PRIVATE LIBERAL ARTS COLLEGE

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Biology Department	C-5
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LAB PACK WASTE CHEMICALSWASTE MATERIALAPPROXIMATE AMOUNT

Ether/nitromethane (<1%)	15 L
Acrylic acid	150 mL
Pump oil	3 to 4 gal
Acetic acid	4 L
Aqueous mercuric chloride	17 L
Polychlorinated biphenyls (PCB'S)	small vials am to about
Xylene	3 L
Styrene	200 mL
Chloroform and iodine	4.5 L
Chloroform and water	2 L
Lamp oil/trichloromethane	2.5 L
Ethylene dibromide	3 gal
Thionyl chloride	15 mL
3-carbomethoxypropionyl chloride	20 mL
Hexane/dicyclopentadiene	3 L
Used mercury	3 L

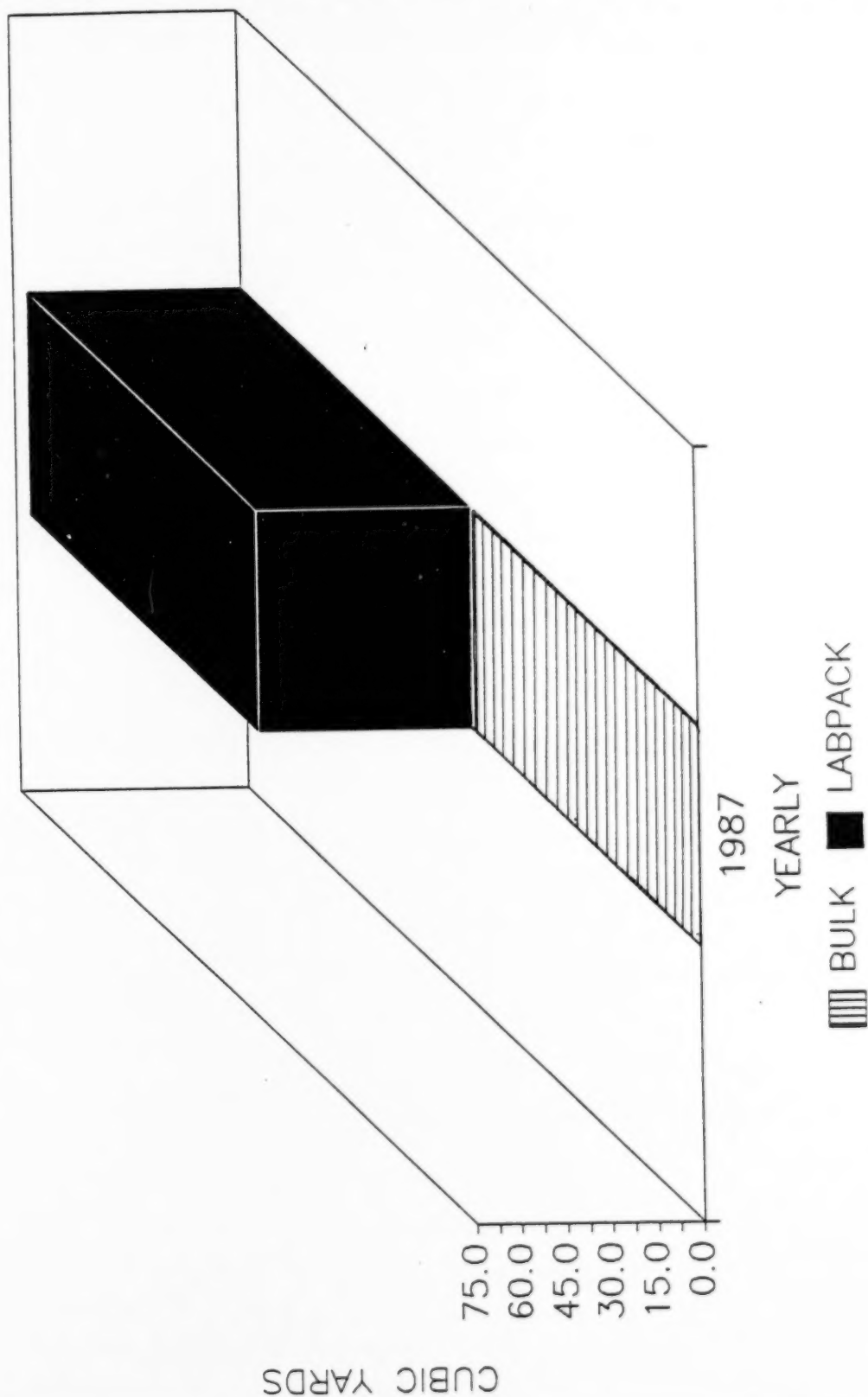
OXIDIZERS

Sodium dichromate/sulfuric acid (chromerge)	2 L
48% hydrogen bromide in water	400 mL
Stannic chloride	400 mL
Chromium trioxide	300 g
Antimony pentafluoride	100 g
Sodium peroxide	200 mL
Sodium dichromate/dilute sulfuric acid and ether	2.5 L
Budget-Solv (TM) high flash point cocktails	33 L

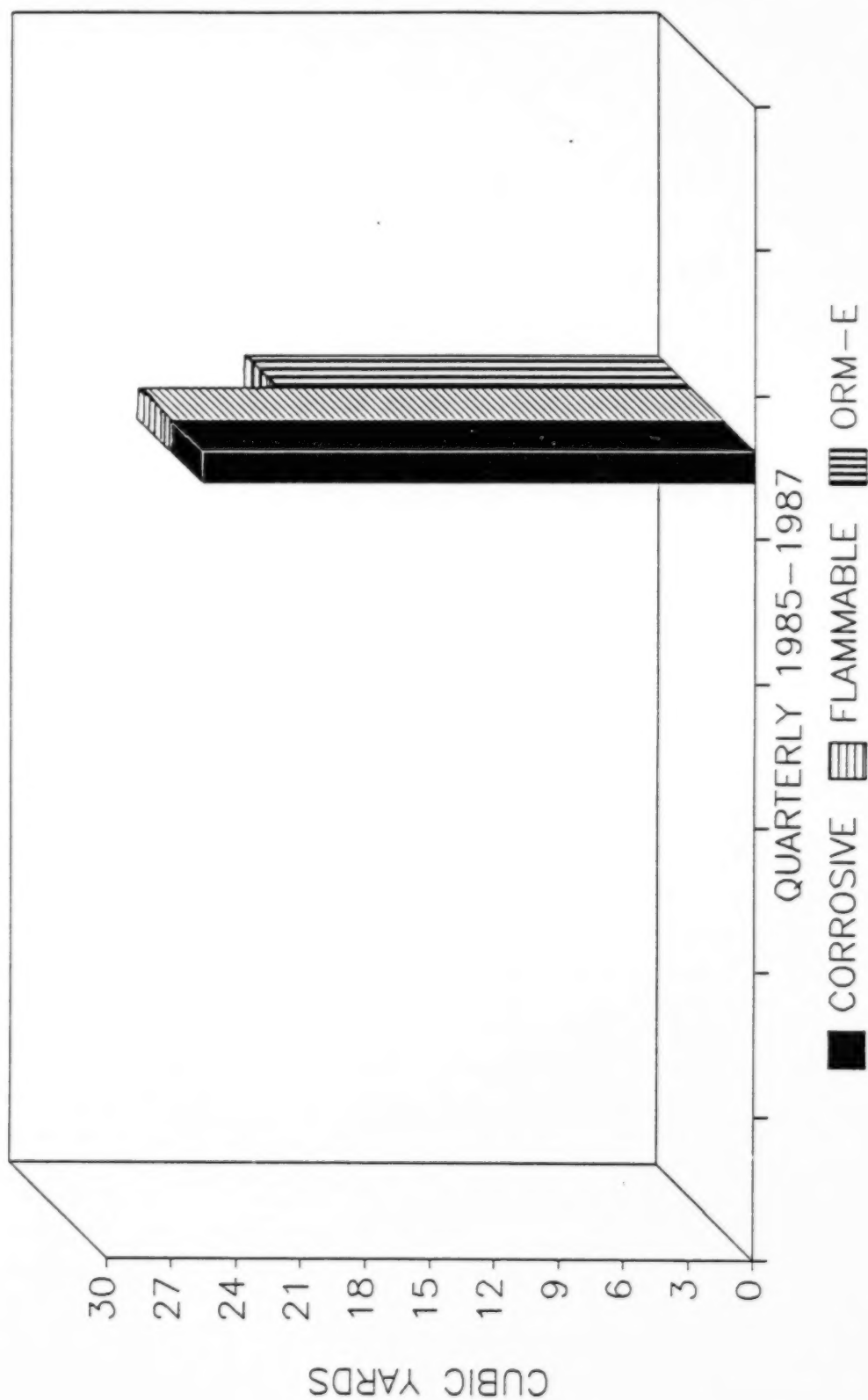
OTHER WASTE MATERIALS

Methyl mercuric chloride 250 ppm	1.5 gal
Methyl mercuric chloride	400 mL
Glutaraldehyde 4% in water	1 L
Petroleum ether	5 gal
Osmium tetroxide	30 mL
Xylene	4 gal
Chromerge (sodium dichromate in sulfuric acid)	7 gal
Xylene/toluene/EtOH	6 gal
Glutaraldehyde/osmium tetroxide/toluene	2 L

SMALL UNIVERSITY CHEMICAL WASTE DISPOSAL - LABPACK VS. BULK



HAZARDOUS WASTE DISPOSAL FOR THE SMALL PRIVATE COLLEGE



RALPH STONE AND COMPANY, INC.
SMALL UNIVERSITY
WASTE CHEMICAL
MANIFEST DATA

	DATE	WASTE NO.	CHEMICAL	CLASSIFICATION	TYPE	Disposal Packaging	Lab Pack List	Quantity (cu yd)
1	01/08/87	122		Corrosive	Liquid	Lab pack	Yes	12.84
	01/08/87	331		Corrosive	Liquid	Lab pack	Yes	6.42
	1/08/87	331		ORM-E	Liquid	Lab pack	Yes	6.42
	1/08/87	331		Flammable	Liquid	Lab pack	Yes	12.84
	01/16/87	331		Flammable	Liquid	Lab pack	Yes	6.42
	1/16/87	551		ORM-E	Liquid	Lab pack	Yes	6.42
	3/19/87	144		ORM-E	Liquid	Lab pack	Yes	6.42
	03/19/87	331		Flammable	Liquid	Lab pack	Yes	6.42
	03/19/87	331		Corrosive	Liquid	Lab pack	Yes	6.42

Total 70.62

QUARTER TOTAL 70.62

QUESTIONS FOR BIOLOGY DEPARTMENT ON CHEMICAL USAGE AT
SMALL, PRIVATE LIBERAL ARTS COLLEGE

Attendees:

- 1) Describe your position with the Biology Department.
- 2) Describe the types of chemicals used in undergraduate biology labs, graduate labs?
- 3) Which biology undergraduate and graduate subdivision generated the most amount/most toxic waste?
- 4) Where are chemicals stored and dispersed from?
- 5) What kinds of wastes are generated from undergraduate lab exercises? From Graduate/Research?
- 6) Has chemical usage changed over the years as a result of increased environmental and safety regulations.
- 7) Has there been an increase in instrumentation in lab exercises? How has this affected chemical usage and waste generation?
- 8) In chemistry there has been more use of "micro-scale" labs which utilize small glassware, which in turn results in less chemicals used. Is this being done in biology? If not, is this approach feasible?
- 9) Can certain waste be treated/destroyed as part of the experimental process?
- 10) Have any waste reduction strategies already been implemented?
- 11) What recommendations could you offer to reduce chemical waste generation in biology labs?

QUESTIONNAIRE FOR ARTS DEPARTMENT ON CHEMICAL USAGE AT
SMALL LIBERAL ARTS COLLEGE

Attendees:

- 1) What areas/disciplines in the department use chemicals?
- 2) What kinds of chemicals are used in each of these areas?
- 3) What waste streams are generated in each of these areas?
- 4) What changes in chemical usage have occurred in recent years as a result of increased awareness of chemical hazards and environmental issues?
- 5) Is it possible to substitute less toxic/hazardous chemicals (i.e. use of water based paints instead of oil based paints, etc.)?
- 6) Do you have any recommendations, suggestions for other ways to reduce waste generation?

**ORDER FORM FOR CALIFORNIA HAZARDOUS WASTE CONTROL
LAWS AND REGULATIONS**

Copies of hazardous waste control laws and regulations administered by the California Department of Health Services may be ordered by completing the form below and mailing it with the applicable payment to:

Department of General Services, Publications Section
P.O. Box 1015
North Highlands, CA 95660

The laws and regulations are *not* identical, so both are generally needed to obtain complete information.

The laws (Chapters 6.5 through 6.98, Division 20, California Health and Safety Code) were enacted by the Legislature. Recent history indicates that the laws change to some extent each year, usually effective January first. To keep up to date with the laws, reorder them each year, because no amendment service is available.

The regulations (Chapter 30, Division 4, Title 22, California Administrative Code) were adopted by the Department of Health Services within the scope of the DHS' authority under the laws. The regulations may change at any time during the year according to specified administrative procedures. Therefore, continuous amendment service is available by subscription. The amendment service is useful only in conjunction with the complete regulations (i.e., Division 4, Title 22, CAC).

I. Please check all applicable boxes and complete all applicable blanks.

- ☐ Please send me _____ copy(ies) of *Item No. 7540-958-1016-6, Hazardous Waste Control Law* (Chapters 6.5 — 6.98, Division 20, Health and Safety Code), at \$13.35 per copy, including postage, taxes, and handling costs. \$ _____
- ☐ Please send me _____ copy(ies) of the regulations (Division 4, Title 22, California Administrative Code (CAC)) at \$8.48 per copy, including postage, taxes, and handling costs. \$ _____
- ☐ Please accept my _____ subscription(s) to the continuous amendment service for the regulations (Division 4, Title 22, CAC) at \$12.00 per subscription per year, including postage and handling costs. The complete regulations must be ordered separately by checking the applicable box. \$ _____

Make check or money order for the total amount payable to: State of California.

TOTAL AMOUNT \$ _____

I. Please print or type your mailing address and telephone number below; then sign and date the form.

Name/Company Name _____

Attention _____

Address _____

City _____ State _____ Zip _____

Telephone Number _____ (In case we need to contact you about your order)

Signature _____

Date _____